農事試驗場歐文報告

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IMPERIAL CENTRAL AGRICULTURAL EXPERIMENT STATION

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Studies on the Fruit-Flies of Japan.

Contribution I.—**Japanese Orange-Fly.**

BY

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With Plates II.—X. and five Text-Figures.

CONTENTS.

I. INTRODUCTION.

Japan, like other countries, is not exempt from the attacks of various noxious insects, yet the orchards in the Main Island (Honshiu) are not suffering at present from any injury caused by fruit-flies (Trypaneidae). It is true that certain species of flies belonging to the family are found in Honshiu, yet, so far as I could observe, none of them seem to cause any damage at all to our orchard fruits.[1] Recently it was reported that the fruit of *Elaeagnus* in the Prefecture of Shidzuoka,[2] and cherries in the Prefectures of Akita and Aomori,[3] were infested by some dipterous insects, but after examination, I could confirm that they were not Trypaneids. Some observant people in Honshiu may be acquainted with certain lepidopterous larvae burrowing in the pulp of the pear and the peach, but no one would ever suspect that there are maggots in the pulp of the orange. However, it is occasionally reported that, in the warmer parts of Japan, Kiushiu and Formosa, there occur some fruit-infesting maggots, which cause not inconsiderable injury to oranges. Though very few Trypaneids have been reported from Japan proper,[4] yet quite a large number have recently been mentioned as from Formosa by HENDEL (12, 13)[5] and ENDERLEIN (8), and now we know that the very injurious orange-infesting species, commonly known as *Komikanbai* in that

1. Quite recently I was informed that, at some localities in Gifu Prefecture a Trypaneid, apparently *Chaetodacus* (but not *C. cucurbitae*) was discovered, which infests the pumpkin. TAKAHASHI (32) gives some details. (The figures in parentheses refer to the bibliography appended at the end of the present paper.)

2. OKADA (24).

3. NISHIGAYA (23).

4. Prof. MATSUMURA of the Sapporo Agricultural College has described (21, p. 117, Pl. xxviii, fig. 8) 1 species occurring in Hokkaidō, and (22, pp. 411–423, pl. xxiii, figs. 9-19) 11 Trypaneid species (assuming all to be true Trypaneids), of which 8 occur in Japan proper, 1 in Loochoo, 1 both in Japan and in Formosa, and 1 both in Japan and in Saghalien.

5. Figures in parentheses refer to the bibliography.

island is referable to *Dacus*[1] (*Chaetodacus*) *ferrugineus dorsalis* of HENDEL. On the other hand, so far as I know, no species from Kiushiu has been described systematically. It has been stated that the well known injurious melon-fly (*Dacus* (*Chaetodacus*) *cucurbitae* Coquillett) was reared by COMPERE (3, p. 4) from melons and cucumbers collected at Nagasaki, a port in Kiushiu, and if this is really so, there can be no objection to including Kiushiu in "Japan," as used by PERKINS (28, p. 179) and CRAW (3, p. 4) in their works (The former author maintains the true home of the fly to be Japan or China, and the latter states, that the fly was introduced from Japan into Hawaii). However, since repeated investigations made by me at Nagasaki failed to confirm these statements, I am confident that they are incorrect.[2]

On the other hand, the presence of a certain orange-infesting fruit-fly has repeatedly been reported of late from the orchards of Kiushiu, and now and then it has also been mentioned by our entomologists in various Japanese journals. By KUWANA (17), the species was referred to *Dacus* (*Chaetodacus*) *ferrugineus* Fabricius, and its morphology, brief life-history, distribution and control measures were described by him in the Report of the Imperial Agricultural Experiment Station (18).

In 1914, I was asked by the Department of Agriculture and Commerce to inspect the actual conditions of this orange-pest infestation in the invaded districts of Kiushiu. The results of my observation were afterwards presented to the authorities in an official report, which consisted of itinerary records and some scientific investigations. From my inspection, I am able to state that there have been two species of fruit-flies occurring at the orange groves of the invaded districts of Kiushiu, the one, the species known as very injurious aud identified as *Dacus ferrugineus* Fabricius by KUWANA, the other, hitherto an unrecorded species, which I considered to be new to science and which I have named

1. I use here the broad generic name; for the reason see p. 92.

2. While the present work was in the press I received a paper "The Melon Fly" by BACK and PEMBERTON (U. S. A. Dept. Agric. Bull. No. 643, March 8, 1918), in which the former statement was more or less amended to:—"There is some doubt at present about its occurrence at Nagasaki, Japan."

Dacus (*Chaetodacus*) *bezzii*. My subsequent study revealed that the former species was also a new species, to which I have given the new name *Dacus tsuneonis*. The two species were found abundantly at the localities, either singly or in company with each other. Though it is quite obvious that *Dacus tsuneonis* is a formidable pest to the orange, yet *Dacus* (*Chaetodacus*) *bezzii*, abundant as they are at the orchard, have afforded as yet no positive proof of causing injury to the orange. I, therefore, first began with the study of the injurious species *Dacus tsuneonis*, intending in the course of my research, to extend the investigation over the other species, *Dacus* (*Chaetodacus*) *bezzii*, as well as over the whole family of Trypaneidae occurring in Japan. Now that my study on *Dacus tsuneonis* has been nearly completed, I intend to publish what is ready, as the first contribution of my study of the Trypaneidae or fruit-flies of Japan. At the same time, I make use of this occasion to touch upon the specific description of *Dacus* (*Chaetodacus*) *bezzii*, as well as on the descriptions of four other new Trypaneid species, which have been discovered during the course of my study.

Since the presence of this pest is strictly restricted to a limited area in Kiushiu, orchardists of the Main Island of Japan need not be unduly alarmed, though some appropriate precaution against such injurious insects may not be altogether unnecessary. Still less need foreign fruit importers be alarmed, as fruits from these localities are not exported.

To investigate the possible injury by fruit flies, other government entomologists besides myself were sent in 1916 to the principal orange growing districts of the Main Island, but not a single trace of the presence of any fruit-fly was found in the localities traversed. In spite of this it is desirable to keep constant watch and guard against invasion by the above-mentioned species a well as other fruit-flies.

The author desires to express here his hearty thanks to Prof. M. Bezzi of Italy, who has favoured him with much valuable advice in the course of this investigation. Grateful acknowledgments are also due to Messrs. K. W. Dammerman, W. W. Froggatt, W. M. Giffard, L. O. Howard, J. F. Illingworth, C. W. Mally, J. C. H. de Meijere,

F. Muir, W. C. O'Kane, H. H. P. Severin, H. C. Severin, F. Silvestri, N. Yatsu and many others, for friendly information and for the loan of important papers. Further indebtedness is also acknowledged in the text to other gentlemen who have extended their courtesy to the author in special matters.

II. HISTORY, DISTRIBUTION AND DESTRUCTIVENESS.

Of the early history of the species under consideration I cannot say anything with certainty, yet it is highly probable that the fly is an indigenous species, inasmuch as it has not been recorded from other parts of the world. With regard to the question as to the place in Kiushiu where it originated, I cannot give any definite answer, although we naturally suppose it to be somewhere in Ōita or Miyazaki Prefecture, since the flies are at present very abundantly found in those prefectures.

As said before the occurrence of the present species is strictly limited to Kiushiu and the following table gives the detailed distribution in that island :—

Ōita Prefecture	Ōita City; Kita-amabe District	Tsugumi Village, Aoye Village, Shitaura Village, Hijiro Village, Usuki Town.
	Minami-amabe District	Meiji Village.
Miyazaki Prefecture	Higashi-morokata District	Takaoka Village, Aya Village.
	Koyu District	Mino Village, Kamihokita Village.
	Higashi-usuki District	Nobeoka Town, Okatomi Village, Tsunetomi Village, Minamikata Village, Kitakata Village.
	Nishi-usuki District	Nanaori Village.
Kumamoto Prefecture	Hōtaku District	Kawachi Village.
	Tamana District	Obama Village.
Nagasaki Prefecture	Kita-matsuura District	Hirado Village.

Kagoshima Prefecture.	Kagoshima District	Sakurajima Village, Nishisakurajima Village, Take Village, Fujino Village.
	Aira District	Fukuyama Village, Yamada Village.
Fukuoka Prefecture[1]...	Yame District.	

Of the localities above mentioned, the injury is more serious in Ōita, Miyazaki and Kumamoto Prefectures than in any other.

An exact estimation of the damage is impossible, since it varies from year to year according to climatic and many other conditions. Speaking generally, however, where the destruction is severest, it is said, often to amount to 40%–50% of the whole harvest, yet usually it is 10%–20% or still less. Fortunately, according to reports recently received from the various infested localities, the damage is being reduced year by year chiefly owing to the improvement and strict execution of preventive measures.

III. TECHNICAL DESCRIPTION.

1. Systematic Description.

DACUS[2] *TSUNEONIS*[3] n. sp.

(Nom. Jap. *Mikanbai.*)

(Pl. II., fig. 1, ♀; Pl. X., fig. 1,—wing.)

Dacus ferrugineus Kuwana (nec Fabricius), (17), p. 109 (1911).

A conspicuously large species, the prevailing colour of the body ochreous; all the bristles are black.

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1. The occurrence of the fly has been reported here, but cannot be verified.

2. Here I have to adopt the genus *Dacus* in a broad sense and do not use it as a subgenus or small genus (some authors elevate the subgenus into the genus), since the present species cannot be included in any subgenus hitherto described, so that a new subgenus (I call it *Tetradacus*) must especially be created in order to include the species. However, at present, I entertain some doubt as to whether it is scientifically proper to establish a new subgenus, taking merely such a very small point into account. For this reason in the present paper, all the species are included within the broad genus *Dacus*, without using any subgenus such as *Chaetodacus*, *Bactrocera*, etc.

3. Named after my dear son, Tsuneo who was born in 1914, when I began the present study, and who died in 1916, when I finished the first draft of this contribution.

Head yellow or ochreous; ocellar triangle black; frons in some specimens tinged with fuscous; antennal ridge in most specimens dusted with fuscous; Eyes reddish brown, with dark-green reflection[1]; two shining black claviform spots on the clypeus; a small subtriangular piceous spot in the middle of each gena, just below the lower margin of the eye; antennae ochreous, the arista piceous, with the base yellow; proboscis, with a piceous ridge at the base, mottled with brown, the palpi yellow.

Thorax densely punctate, with short yellowish pubescence, ferrugineo-ochreous; a median longitudinal λ-shaped purplish testaceous streak on the dorsum, terminating posteriorly in the centre of the scutum; a pair of rather faint submedian, more or less wavy, purplish testaceous lines, interrupted at the transverse suture and united posteriorly with the posterior branches of the λ-shaped streak just mentioned; a yellowish patch, often defined internally with piceous line on each humeral callus, extending posteriorly to the transverse suture; an anteriorly acutely-pointed, subtriangular yellow spot on the space, bounded by the posterior branches of the λ-shaped streak; a long lunular yellowish streak defined internally with a piceous line on each side of the spot just mentioned, commencing anteriorly at the transverse suture and ending posteriorly before the junction of the scutellum; anterior and posterior supra-alar bristles double; scutellum yellowish, with two bristles; the median plate of the scutellum ochreous; the lateral sides of the thorax ochreous, except the postscutellum and most of the lateral plate of the mesosternum, which are yellow; an elliptic yellow patch at the mesosternum, close to the suture; halteres ochreous; the chaetotaxy is peculiar, with two pairs of supra-alar bristles and without praescutellar bristles.

Legs ochreous, with yellow pubescence; the apical margin of the fore coxae and the internal sides of the mid coxae with a few black hairs; end of all the femora, base and end of all the tibiae, and distal

1. In the living specimen they are bright green with purplish reflection.

joints of all the tarsi, brownish; the internal sides of end of the femora and end of the tibiae often with a testaceous streak.

Wings hyaline, with more or less greyish tinge; veins fusco-ochreous; pterostigma fusco-ochreous; the area between veins *R*1. and *R*4+5. tinged with honey-yellow; radial cell at the region above the medial and cubital cells also honey-yellow; a fuscous suffusion at the apex of the wing; The second axillary lobe wanting in the male.

Abdomen oval, as broad as the thorax, densely punctate, bright ochreous above, yellowish beneath, and brownish at the end, with a short yellowish pubescence; a longitudinal median black, rather broad, streak from the base to the end of, or four-fifth of, the apparent fifth segment,[1] where it is usually attenuated; the streak is slightly dilate at the anterior margin of the second segment; along the anterior margin of the third segment, there is a slightly broader, transverse piceous band which constitutes a cross marking with the above-mentioned longitudinal streak; a pair of still broader, transverse testaceo-piceous bands at the anterior margin of the fourth segment, neither confluent with each other nor with the longitudinal streak; in some specimens, there is often another pair of piceous bands at the anterior margin of the fifth segment.

In the male there is a row of black hairs (7–10 in number) on the sides of the posterior margin of the third segment; in the female the basal segment of the ovipositor (apparent seventh segment) is bottle-shaped, ferrugineo-ochreous, as long as the fourth and fifth abdominal segments taken together.

Male. Length of body 10 mm.; length of wing 9 mm.

Female. Length of body 11 mm. (measured to the origin of the basal segment of ovipositor); length of wing 10 mm.

Described from 10 male and 10 female specimens captured at Tsugumi, on Aug. 28, 1915; besides many others examined.

Local Distribution. Ōita, Miyazaki, Kumamoto, Nagasaki, Kagoshima, Fukuoka (?).

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1. For convenience sake, here as well as in subsequent systematic descriptions, the visible abdominal segments alone are numbered.

Habitat. Kiushiu.

This species was first reported from Japan as *Dacus* (*Chaetodacus*) *ferrugineus* Fabricius by KUWANA (17, 18). However it entirely differs in its chaetotaxy as will be described later. It is also different from *Dacus* (*Chaetodacus*) *ferrugineus* described by WIEDEMAN, in the markings of the abdomen, and from that by BEZZI, in its black bristles. Furthermore, the present species is larger than *ferrugineus*, which is reported to be 5–7 mm. in length. Specimens have been submitted for examination to Prof. BEZZI, who remarked that it differs from *ferrugineus* by its black head bristles and by the peculiarity of its ovipositor.

The present species does not bear the praescutellar bristles, and in the male the hind border of the wing is not indented at the end of the anal vein. In these, also in many other respects, it is closely related to the Ethiopian species and stands very near the subgenus *Tridacus*.[1] However, in the present species, there are four supra-alar bristles, both anterior and posterior being paired, so that if the subgenus may be adopted, a new subgenus *Tetradacus*, with four supra-alar bristles, should be created to include the present species.

2. EXTERNAL STRUCTURE OF THE ADULT FLY.

a. *HEAD*[2] (Pl. II., figs. 10, 11, 12).

The head of this insect is comparatively large, and contains many regions, on the morphological terms for which there are, as in other flies, many different opinions. The top of the head we call the vertex (Pl. II figs. 10, 11, *v.*), where three ocelli (*s. e.*) are situated on the raised black ocellar triangle. The front of the vertex is the frons (*f.*), which bears three pairs of bristles, the hind pair of which are bent backwards and are called the superior front orbital bristles (*s. f. o.*), and the middle and front pairs, which are bent inwards, are called the inferior front orbital

1. BEZZI (5, p. 86).

2. In the following description, I mostly adopt HEWITT's orismology employed in his "House-Fly" (14), excepting names of bristles and other portions of the body which are peculiar to the fruit-fly. For these I mainly follow BEZZI's usage.

bristles (*i. f. o.*). Lateral to the frons and the vertex are a pair of large hemispherical compound eyes (*c. e.*), reddish purple in colour, with metallic blue-green reflection in life, and dark reddish purple with slight green reflection after death. The lower part of the frons forms a ridge (fig. 11, *a. r.*) ("antennal ridge" according to LOWNE, 19), below which arise the antennae (figs. 10, 11, *a.*), each of which consists of three joints and the arista. The sclerite below the antennae is called the clypeus,[1] (fig. 11, *c.*) or the face, and the region between this and the compound eyes is known as the gena (fig. 11, 12, *g.*), which bears the genal bristles (fig. 11, *g. b.*). The lower edge of the clypeus, which forms the margin of the so-called proboscis aperture, is the episternum (*e.*). To the proboscis aperture the retractible proboscis is attached, which is composed of two portions—the rostrum and the haustellum. The rostrum (figs. 11, 12, *r.*), which is the portion proximal to the head, has the shape of a truncated cone, and bears on its lower side a pair of rather conspicuous leaf-like appendages known as the maxillary pulpi (*mx. p.*). The haustellum (fig. 11, *h.*), the distal portion, is again composed of two parts—the proximal conico-cylindrical and distal lobe-like parts, of which the former is said to represent morphologically a certan part of the labium. The posterior side[2] of the part is known by the name of the theca (fig. 12, *th.*). On the anterior[3] median line, there lies a claviform processus, arising from the basal portion of the haustellum. This is called the labrum-epipharynx (fig. 11, *l. ep.*), morphologically considered it corresponds to the labrum and epipharynx. Beneath the labrum-epipharynx is a longitudinal groove, lined with chitinous ridges well adapted to receive the processus. In some other kinds of flies there is usually another processus called the labium-hypopharynx, under the labrum-epipharynx just mentioned, but so far as my examination went, I could not find any corresponding organ in this species. However, in certain cases, I found a very small, short, quadrate piece at the root of the labrum-

1. LOWNE (19) applies this term to the basal portion of the proboscis.

2, 3. The words "anterior" and "posterior" are applied to the proboscis in position, as it hangs perpendicularly from the head capsule.

epipharynx, which, if I am not mistaken, may be considered as the labium-epipharynx. At the end of the haustellum, is a fleshy, broadly U-shaped disc, called the oral lobe or labella (figs. 11, 12, *o.l.*), which is for sucking food. The distal surface of the labella contains a number of channels, called the pseudo-trachaea (fig. 12, *p.s.*).

On the posterior side of the head, one may find the occipital foramen (fig. 12, *o.f.*) in the centre, around which there are four sclerites, the middle dorsal one of which is the occiput (*oc.*) (HEWITT calls it the epicranium and LOWNE the mesocranial plate), the middle ventral one the gulomental plate (*g.m.*) (or pars basilaris), and the lateral two are known as the genae (*g.*) (HEWITT) or paracephala (LOWNE).

b. *THORAX* (Pl. II., figs. 3, 4, 13).

The thorax of the present insect, like that of other flies, represents a considerable modification. The entire segment, which is chiefly composed of the mesothorax, constitutes a slightly elongate box, which is oviform when seen from above. The prothorax is very small, only visible at the anterior side of the main thoracic segment. The lateral region of the prothorax is chiefly represented by a sclerite (the episternum, according to HEWITT) and there the anterior thoracic spiracle lies (Pl. II., figs. 3, *t.s.*) between this and the mesothoracic selerite. Of the mesothorax, the notum constitutes almost the entire dorsal surface of the thorax and is composed of the praescutum, scutum, scutellum and the postscutellum. The praescutum (figs. 3, 13, *prs.*) is a sclerite of transverse rectangular form, bounded laterally by the portion called the humerus (*hu.*) and posteriorly restricted by the transverse suture (*t.s.*). The anterior edge of the praescutum bears two pairs of the bristles called scapular bristles (figs. 4, 13, *scp.*), and the humerus bears the humeral bristles. The scutum (figs. 3, 13, *sc.*), which constitutes the largest portion of the mesonotum, is quadrate in shape, and bears, along the lateral sides, the bristles called the anterior and posterior, notopleural (figs. 4, 13, *a. npl.*; *p. npl.*) and supra-alar (*a. sa.*; *p. sa.*) bristles. Of the latter bristles, both the anterior and posterior supra-alar bristles are double in number. The praescutellar bristles, the presence of

which according to BEZZI (4, p. 92) is said to be characteristic of the allied Oriental species, are absent in this species.[1] The scutellum (figs. 3, 13, *sctl.*) is a triangular convex sclerite and bears a pair of bristles called the apical bristles (*a. b.*) in relation to the basal bristles, which are often present in other species. The postscutellum, which is situated behind the scutellum, is composed of three portions, one median (*mp. sc.*) and two lateral plates (*lp. sc.*). Laterally the mesothorax represents highly complicated sclerites aud sutures. According to the orismology of HEWITT—the lateral plate of the mesosternum (fig. 3, *lp.*) is a quadrate plate with two sutures and bears the mesopleural bristles (fig. 4, *mpl.*). The episternum, if my orientation be correct, is the narrow region (fig. 3, *eps.*) posterior to the lateral plate, above which we see the sclerite of the parapteron (*ptr.*). The epimeron (*ep.*) is a subquadrate plate posterior to the episternum, and above it we see the base of the wing. The epimeron bears the pteropleural bristles (fig. 4, *pt. b.*). The mesosternum (fig, 3, *ms.*) is a large triangular plate attached to the lateral plate and to the epimeron just mentioned. The metathorax is greatly reduced and the main part is represented by the metasternum (*mts.*). Just above it is a small oval plate (unmarked in fig. 3), which is probably a portion of the metasternum. Posterior to the metasternum and the lower part of the lateral plate of the postscutellum is an elongate portion (fig. 3 *eps.+ep.*), making the lower posterior edge of the thorax. In *Musca domestica* Linnaeus, according to HEWITT, the portion is divided into two sclerites, the episternum and the epimeron, while in our species, so far as I could ascertain, it appears to be a single plate, the two sclarites possibly having been united. On the upper part of the plate the posterior thoracic spiracle (*p. t. s.*) is situated and above the spiracle is the balancer (figs. 3, 13, *bal.*) or haltere, possibly having originated from a special sclerite.

WINGS (Pl. III., fig. 14; Pl. V., fig. 1).

The fore wings, which represent the wings of the fly, are situated at the sides of the scutum of the mesothorax, above the epimeron of the same segment. They are elongate, membranous and almost transparent,

1. As to discussion of the subgeneric character see p. 95.

except for a portion tinged with brown. Applying COMSTOCK and NEEDHAM'S nomenclature of veins to the present species, there are six kinds of longitudinal veins and a few small cross veins in all, presenting the typical neuration of Muscidae. Indeed, the fruit-fly is still placed in that family by some authors, but differing in several small points it is rather distinct. The costa (Pl. III., fig. 14 *C.*) forms the anterior margin of the wings and is bristly in the species. The subcosta (*Sc.*) arises from the common stalk of the subcosta and the radius (*Sc.*+*R.*), running parallel with the first radial branch (*R* 1.) and ending at the costa, where, in this species, it becomes very indistinct. Between the costa and the subcosta there is a cross vein called the humeral (*h. v.*), by which the costal cell is divided into two cells. The proximal cell (*C.*) is called the costal cell (according to HEWITT, 14) or first costal cell (according to BEZZI, 4), and the distal cell (1 *C.*) is called the first costal cell (HEWITT) or second costal cell (BEZZI). The radius arises from the common stalk (*Sc.*+*R.*) just mentioned and is forked into three branches *R*1., *R*2+3. and *R*4+5., where the typical radius has five branches. In the species the first radial branch (*R*1.) and the basal half of the coalesced fourth and fifth radial branches (*R*4+5.) are bristly. Next, from a rather inconspicuous common stalk, possibly the united portion of the media and the cubitus (*M.*+*Cu.*), two well distinct diverging veins arise, the upper one being the united vein of the first and the second medial branches (*M*1+2.) and the lower one the coalesced vein of the second medial and the first cubital branches (*M*3.+*Cu*1.). Between the R4+5. and M1+2. is a cross vein termed the radio-medial transverse vein (*rm.*) (according to HEWITT), or small cross vein (according to BEZZI). Between the M1+2. and *M*3.+*Cu*1. are two cross veins, of which the proximal one, called the medio-cubital vein (*m. cu.*) (according to HEWITT) or basal cross vein (according to BEZZI), is said to represent the original M_3., the distal one being called the medial transverse vein (*m.*) (HEWITT) or hind cross vein (BEZZI). The cell bounded by the veins *M*1+2. and *M*3.+*Cu*1. is divided by the above-mentioned two veins into three cells. The most proximal cell is called the medial cell (*M*) (HEWITT) or second basal cell (BEZZI), the

next cell the first second-medial cell ($2M^1$.) (HEWITT) or discoidal cell (BEZZI), and the distal cell is termed the second second-medial cell ($2M^2$) (HEWITT) or second posterior cell (BEZZI). The second branch of the cubital vein (*Cu*2.) (anal cross vein of BEZZI) is partly coalesced with the first anal (1st *A.*) at the distal portion. The first anal is as distinct as the other vein, though it is distally fused.

From the base of the anal lobe (*an.*) arises a rather inconspicuous vein (*c. f.*) (axillary vein of BEZZI) which is said to be merely a chitinised furrow and not a true vein. The second axillary lobe is wanting in the male.

HALTERES (Pl. II., figs. 3, 13).

As the present species belongs to the acalyptrate Muscidae, the halteres or the balancers (*hal.*) are not covered by the squamae. They are situated above the posterior thoracic spiracles (fig. 3, *p. t. s.*), quite posterior to the thoracic segment, and are of capitate form.

LEGS (Pl. III., fig. 15, 16).

The legs are composed of the typical segments, *i. e.* coxa (*cx.*) trochanter (*tr.*), femur (*fe.*), tibia (*t.*) and tarsus (*tar.*). On the coxae of the mid and hind legs, there are special regions called the intermediate coxal plates (*c. p.*). On each of the middle legs I could find two intermediate coxal plates, while on the hind legs, as far as I could ascertain, a single plate only was found. The trochanter and subsequent joints are almost similar in all legs. On the inner side of the distal end of the middle tibia are a few piceous setae, one of which is rather prominent. The tarsus is five jointed, with a pair of claws (figs. 15, 16, *cl.*) at its apex, resting on a pair of pads called the pulvilli (figs. 13, 16, *pul.*).

c. *ABDOMEN* (Pl. II., figs. 8, 9; Pl. III., figs. 1, 2, 3, 4).

The shape of the abdomen of this insect differs in the sexes. In the male it is elliptical (Pl. III., figs. 1, 2); in the female, owing to the elongation of the terminal three segments which constitute the ovipositor, it assumes a spindle shape (figs. 3, 4). The apparently visible number of segments also differs in the sexes. In the male we can count five

segments both dorsally and ventrally, with five pairs of visible abdominal spiracles, while in the female, dorsally, five main segments (just as in the male) together with three elongated tubular segments (constituting the ovipositor, described in detail later on)—five segments in all—are to be found, while ventrally there are six segments, besides the three tubular-segments, with six pairs of abdominal spiracles, the last segment, which is invisible dorsally, lying beneath the terminally visible segment of the dorsal side, so that if the segment is lifted up it can easily be seen. Thus in the female, nine segments are distinguishable. Though an exact determination of the number of abdominal segments is very difficult without embryological study, after a minute observation, it appeared to me to be rather reasonable to distinguish eleven segments in both sexes, as shown in Pl. II. figs. 8, 9 and Pl. III., figs. 1, 2, 3, 4. As can be seen from these figures, at the ventral side of the base of the abdomen, there are membranous segment-like portions, which I consider to be ths first and second abdominal segments. Thus, if these two segments be added to the visible nine abdominal segments of the female, they amount to eleven segments in all. In the male, the two supposed segments being added to the five visible segments already known, and to the other modified segments that constitute the basal portion of the genitalia, also make up eleven segments in all. Regarding the details of the genital parts explanation will be found under their own headings.

Male Genitalia (Pl. II., figs. 5, 6, 7, 14; Pl. III., fig. 8, 9, 10, 11, 12, 13, 14).

The abdominal extremity of the male, in which four segments have to be discriminated, is usually concealed by the notum of the seventh segment (Pl. II., fig. 7). The sagittal plane of these four segments tends slightly to the left. Pl. III., fig. 8 shows that this was turned back to the right, as shown by the arrow,[1] in order to coincide with the main sagittal plane of the body. Next to the seventh abdominal segment lies a rather large cylindrical segment which I take to be the ninth segment (Pl.

1. As the figure is drawn in the ventral aspect, the arrow that shows the rightward turning may appear to indicate a leftward direction.

II., figs. 5, 6. 7). Close to the sternum of the seventh, there is a narrow chitinous bow, from the middle of which arises, towards the right, another small chitinous bow (Pl. III., fig. 8, *VIII.*). These two chitinous bow, especially the basal larger one, I regard as the eighth segment. Near the top of the distal smaller one, another irregular chitinous piece (*c. p.*) runs backwards along the middle of the ninth segment. Posterior to the ninth segment, there is a rather small barrel-shaped segment (*X.*), provided ventrally with a pair of chitinous processes (*un.*), each having two pointed apexes. I consider this the tenth segment and call the processes the uncus, which may probably take part in copulation. Posterior to the tenth segment, usually withdrawn into that segment, there is still another smaller cylindrical segment (*XI.*) with the vertical slit-like opening of the anus. This should be the eleventh segment (figs. 6, 14). The organ which is considered as the penis is a long spiral chitinous rod (*p.*), arising from the apex of the chitinous elevation that lies on a crown-shaped area lying at the posterior end of the median ventral side of the ninth segment. The rod of the penis thence comes to the dorsal side around the right side of the ninth segment, where it curves first anteriorly then posteriorly, forming a ω-formed coil, turning again to the right side of the segment running more closely to the eighth segment than the coiled portion just mentioned, and finally ending in an elongate swollen apical portion. This portion is imbedded in a pocket under the eighth segment, so that it is usually invisible if it is not uncoiled (See Pl. II., fig. 5). The spiral portion of the organ consists chiefly of a dark reddish chitinous rod, lined along its one side (Pl. III., fig. 12) with a hyaline transversely striated cord. The apical swollen portion (fig. 11) is of a rather complicated structure, partly transparent and partly opaque. The apical end represents the structure of a network (fig. 13) enclosing polygonal areas. Near the apex a rather long transparent cylindrical processus arises, with many small setae on its top. The structure of the apical end of the penis seems to differ in each species. For comparison I have drawn that of *Dacus* (*Chaetodacus*) *ferrugineus dorsalis* Hendel in fig. 10, and *Dacus* (*Chaetodacus*) *bezzii* mihi in fig. 9.

FEMALE GENITALIA—OVIPOSITOR (Pl. II., fig. 9; Pl. III., figs. 3, 4, 5, 6, 7, 17, 18, 19).

The ninth abdominal segment in the female is in the form of a bottle upside down, into which the tenth and eleventh segments are telescoped when they are in disuse (Pl. II., fig. 9; Pl. III., fig. 4). For convenience, I call this the basal segment of the ovipositor. The tenth segment is long and cylindrical, the basal half being provided with a dorsal and a ventral pair of slender chitinous rods. The terminal half is almost entirely membranous. This can be considered as the intersegmental membrane between the tenth and eleventh segments, though I could not find any such membrane between the ninth and tenth segments (Pl. III., fig. 17). The eleventh segment (fig. 17, *XI.*), which acts as the ovipositor[1] is a long, slender, sharp-pointed, spear-like body, with a hard chitinous rod along the lateral side, leaving a groove between the two rods dorsally and ventrally. The apex of the ovipositor (fig. 5) is pointed like that of a spear, being provided with three projections which end in roundish tips. The length of the ovipositor, which is about 2 mm. in this species, always slightly surpasses the thickness of the rind of an orange on the day when the fly has to oviposite, so that eggs can be placed into the pulp. The end of the vagina and of the intestine also lead into the ovipositor, the course of which the writer did not succeed in tracing. For comparison I have drawn the ovipositor of *Dacus* (*Chaetodacus*) *ferrugineus dorsalis* Hendel in figs. 7 and 19, and that of *Dacus* (*Chaetodacus*) *bezzii* mihi in figs. 6 and 18.

3. INTERNAL STRUCTURE OF THE ADULT FLY.[2]

a. *ALIMENTARY SYSTEM* (Pl. IV., fig. 2).

The general structure of the alimentary canal is not essentially different from that of the house-fly. It commences anteriorly at the

1. Most entomologists call this the pseudo-ovipositor to distinguish it from the true ovipositor of Thysanura, Orthoptera, etc.

2. Of the internal structure of the fly, I have to omit the descriptions of the muscular, respiratory, circulatory and nervous systems, as all of these require further special study, and are rather far from the aim of the present investigation.

pharynx found in the proboscis. The pharynx then leads to the slender duct termed the oesophagus (*oe.*), which opens at the junction of the head and thorax into a round vesicle known as the proventriculus (*pv.*). At the spot where the oesophagus is connected with the proventriculus, a long slender duct arises, which passes through the thorax and opens into a large, transversely distended sac, termed the sucking stomach (*s. st.*) (or the crop according to HEWITT), the function of which is regarded by many authors as the food reservoir. I often experimented by giving the fly raspberry fluid,[1] of which it is very fond, and on dissection I found that the sucking stomach had been quickly filled with the fluid. From a certain number of flies which suddenly died in the course of breeding, I discovered the fact that the sucking stomach was enormously expanded, containing many bubbles which had probably been produced by the effect of the dissolution of excess of food.

To the proventriculus, a long, rather broad duct of almost uniform caliber leads, known as the ventriculus (*ven.*). The posterior portion of the ventriculus is much convoluted at what is termed the intestine (*int.*). The convolution of the intestine is not identical in all the specimens I have examined. The figure shows an example. The posterior portion of the intestine is slightly narrow and continues to a stout duct termed the rectum (*rec.*), which finally leads to the anus.[2]

The salivary gland[3] (*s. g.*), simple in its outer structure, is a pair of slender blind tubes. Running posteriorly through the thorax along the ventriculus, each tube reaches to the middle of the sucking stomach, where it ends, slightly dilated. Anteriorly each tube unites with the other, forming a common duct shortly after it passes into the head, whence it may possibly open into the hypopharynx, as is the case in other flies.

The Malpighian tubes (*mp. t.*) arise as paired ducts at a rather

1. Sold by the name "Ribbon Raspberry" on our market as a drink.

2. In the male, the anus opens immediately after the rectum, while in the female it is very probably opened at the end of the ovipositor, in this, however, I failed to trace its course.

3. I was unable to find more than one set of the salivery glands in the present species, although it is not certain that there are not others.

posterior point of the intestine. Each duct is shortly afterwards divided into two tubules, so that four tubules are seen in the abdominal cavity. These tubules are yellowish, moniliform, much convoluted, and are bound up with fat-bodies and with the intestine.

b. *REPRODUCTIVE SYSTEM* (Pl. IV., figs. 1, 3).

Male Organs (fig. 3).

The male reproductive organs consist of testes, vas deferens, ejaculatory duct, ejaculatory sac and accessory glands. Each testis (*te.*) is a yellowish elongate cylindrical body, the one end, where it is more or less convoluted, being narrower than the other. From the broader end of each testis a narrow duct (vas deferens) arises, which meets a slightly broader median duct known as the ejaculatory duct. At the spot where the vasa deferentia (*v. d.*) open into the latter, many (about 16) blind tubes (*ac. g.*) are attached, possibly forming glands accessory to it. The ejaculatory duct (*e. d.*) leads to a large fleshy sac, which may be called the ejaculatory sac (*e. s.*), if I may adopt Hewitt's nomenclature in the case of the house-fly. The ejaculatory duct may, shortly afterwards, open into the penis, but I did not succeed in tracing its course.

Female Organs (fig. 1).

The female reproductive organs consist of ovaries, oviducts, spermatheca and accessory organs with their ducts, and the vagina. Each ovary (*ov.*) is roughly of spherical form, composed of many (about 30) egg-tubes, each of which contains an elongate fusiform egg when matured. Each egg bears on the apical side a massive body, which should be considered as the distal portion of the ovarian tube. Yet I could not find any serial undeveloped eggs in it.[1] (For the egg see p. 107). The ovarian eggs do not develop for some days[2] after emergence, so that the ovary is hardly visible. Even when the eggs are ripe, the size of the ovary is not so large as one might expect, as is the case with the house-

1. The observation was made during a temporary stay at Tsugumi Village, where arrangements for microscopic study were not available.

2. I examined several specimens during the three days after their emergence.

fly in which it occupies "the greater part of the abdominal cavity." On the day of the maximum emergence of flies, I dissected some examples and counted the mature eggs contained in each ovary. They are as follows :

Table I.

Number of Eggs in the Right and Left Ovaries.

Date.	Eggs in the right ovary.	Eggs in the left ovary.
Aug. 1, 1915	18	19
,, ,,	26	10
Aug. 5, ,,	7	8
Aug. 7, ,,	22	19
,, ,,	27	15
,, ,,	26	28
,, ,,	30	24
,, ,,	23	18
,, ,,	27	25
,, ,,	16	28
,, ,,	23	21
,, ,,	31	29
,, ,,	18	20
,, ,,	37	29
,, ,,	16	19

From this fact I conclude that the number of mature eggs in the right and left ovaries are not always equal. However, it has not been established whether this is due to the fact that the eggs in both ovaries do not develop simultaneously or whether mature eggs of both ovaries are differently laid, though the latter case appears to me to be more probable than the former.

From each ovary the short oviduct arises (*ov. d.*), which unite so as to form the common oviduct (*c. ov. d.*). The common oviduct

is suspended by a set of muscles where the spermathecae (*sper.*) open through the ducts, and then leads posteriorly into the vagina (*v.*). Each spermatheca is a small oviform sac with segmented appearance and a blackish centre. The spermathecae appeared to me to be two in number, as far as I could conclude from my repeated observation, although in the apple-maggot fly (*Rhagoletis pomonella* Walsh)[1] and in the house-fly (*Musca domestica* Linnaeus)[2] they are reported to be three.[3] From each spermatheca a winding duct arises, to which a gourd-like vesicle (*ac. o.*) is attached.[4] Both ducts unite into a short common duct and open into the vagina.

4. Egg (Pl. IV., fig. 4).

The mature egg measures about 1.4 mm. in length and .3 mm. in width. It is of creamy white colour and fusiform in shape, obtusely rounded at one end and rather pointed at the other. At the obtuse end there are two small elevations on the egg shell as shown in the figure. The pointed end of the egg is situated proximal to the oviduct, so that when it is laid into the orange, this end goes deeper into the fruit than the other.

5. Structure of the Full-Grown Larva (Pl. V.).

a. *EXTERNAL STRUCTURE* (Pl. V., figs. 1—8).

The full-grown larva (fig. 8) is creamy white with a slight yellowish tinge. Length 12 mm. to 13 mm., width in the broadest part 3 mm. The body is long, conico-cylindrical, pointed at the anterior apex, and is made up of 12 segments.[5] The first segment (or cephalic segment) is trapezoidal,

1. Illingworth (16).
2. Hewitt (14).
3. In a paper (3) received during the printing of this manuscript Back and Pemberton show that two spermatheca are present in the melon-fly (*Dacus cucurbitae* Coquilett) like the present species.
4. In *Rhagoletis pomonella* Walsh (16), *Musca domestica* Linnaeus (14) and *Dacus cucurbitae* Coquillett (3), there is no such vesicle attached to the duct of the spermatheca, but a pair of accessory organs which open independently into the vagina.
5. As to the number of body segments of the dipterous larva, there are many opinions. I have, therefore, for convenience, here recognized only the visible segments, although Hewitt (14) discriminated 13 segments, based on the study of the musculature.

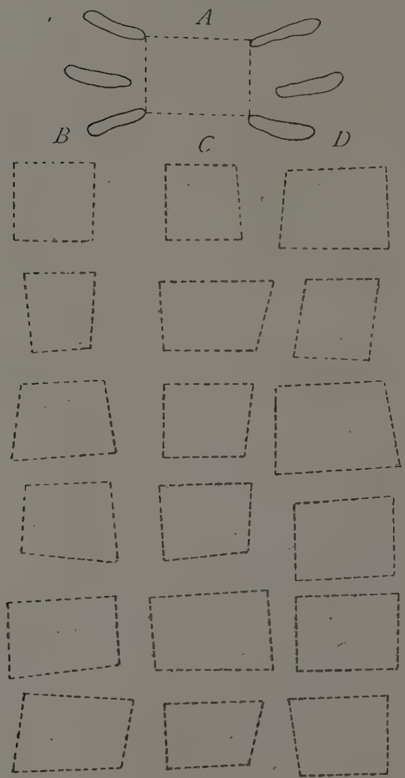
provided with two dorso-ventrally arranged conical tubercles on each side, which are known as the sensory (optic) tubercle or antennal organ (figs. 1, 2, *s. t.*). The oral lobes (*o. l.*) are the convex portions that constitute the lateral sides, which are traversed by about 17 transverse channels, the ventrally placed ones of which are distally biforked. In the middle of the oral lobes, a pair of curved testaceous hook-like bodies (*m. s.*) can be seen, respectively imbedded in a pocket specially adapted to each. They are the anterior portion of the cephalo-pharyngeal sclerites (fig. 3), and are known as the mandibular hooks or sclerites (*m. s.*). When the organ protrudes, each hook is seen to bear a cylindrical cover around its base as is shown in fig. 1. Just beneath the hooks is the entrance to the pharynx or mouth (figs. 1, 2, *mo.*), which is ventrally bounded by a tongue-like body known as the labium or lingual-like processus (fig. 2. *l. p.*). The cephalo-pharyngeal sclerites (fig. 3) are of a very thick chitinous structure, situated within the anterior three segments of the larva, the anterior ends of which are the mandibular sclerites just mentioned. The general appearance of the mandibular sclerites is of a trapezoidal form, one point being produced forwards and constituting the hook already described. The posterior edge of the sclerite articulates to a rectangular piece known as the hypostomal sclerite (*h. s.*). Dorsal to it lies a thin chitinous rod, which I shall call the dorsal hypostomal sclerite (*d. h. s.*). Still posterior to the hypostomal sclerite and forming the base of the cephalo-pharyngeal sclerite, lies a large sclerite, consisting of two irregularly-shaped lateral plates united anteriorly on the median line. The dorsal portion of the anteriorly united region may be called the dorsal pharyngeal sclerite (*d. p. s.*), and the lateral portion the lateral pharyngeal sclerite (*l. p. s.*).

The second segment (fig. 8, *II.*) (the second and third segment of HEWITT) is of a conico-cylindrical form and bears laterally on the posterior border a pair of the T-shaped anterior spiracles (fig. 6), each with numerous lobes,[1] respectively provided with an elliptic aperture at the tip (for comparison I have drawn that of *Dacus ferrugineus dorsalis* Hendel).

1. I have counted 31 in one, and 33 each in two specimens.

The third to the last (twelfth) (fig. 8, *III.—XII.*) segment are usually of similar cylindrical form, gradually enlarging up to the fifth, whence to the tenth they are almost of the same diameter, but at the eleventh and twelfth slightly diminished. Near the anterior border of the ventral surface of each of the posterior eight segments there is a transverse fold furnished with many spinules, called the spiny area (*sp. a.*), which is known as the organ of locomotion. On the last segment (twelfth segment) the anus (fig. 8, *a.*, fig, 13) and the posterior spiracles are situated (fig. 7). The former is a longitudinal aperture on a raised triangular elevation situated somewhat antero-ventrally. The latter are placed rather dorsally on the posterior surface of the segment. They appear as paired elliptic chitinous plates, each of which has three transverse apertures, the middle one of which is placed slightly external to the others. Each aperture (fig. 4) is of an elongate elliptic form, guarded by the chitinous border, which bears many inwardly directed fine hairs and shows internally many partitions, owing to the presence of some chitinous rods that lie across the aperture. Around each spiracle lie five groups of radiating flat hairs (figs. 4, 7, *f. h.*), some of which are branched, each arising from a small round tubercle. In the internally placed groups, the hairs whirl around their respective tubercles.

The forms of the tetragonal figures composed by joining the internally directed apexes of the anterior and posterior apertures (the middle apertures excluded) of the posterior spiracles of both sides, are said, according to GURNEY's statement (11, p. 26, 27), to be quite different in the larvae of different species of the fruit-flies. For example, in *Ceratitis capitata* Wiedemann, it is a transversely long rectangle, while in *Dacus tryoni* Froggatt, it is of a square form. However, as far as I could conclude from my own observations on the spiracles of many examples of the present species as well as of *Dacus ferrugineus dorsalis* Hendel, such figures never represent any definite form peculiar to each species, inasmuch as they vary considerably even in a single species. As the reader may see from text-fig. 1, in a series of examples of the present species, it is transversely rectangular, trapezoidal or sometimes even longitudinally rectangular, and similar



Text-fig. 1.

Various forms of the tetragonal figures composed by joining the apertures of the posterior spiracles:

A, Tetragonal figure of *Dacus tsuneonis* Miyake, with the apertures. × 62.
B, Tetragonal figures of *Dacus tsuneonis* Miyake. × 62.
C, Do.
D, Tetragonal figures of *Dacus ferrugineus dorsalis* Hendel. × 100.

figures can also be observed in that of *Dacus ferrugineous dorsalis* Hendel. At the same time, I could also ascertain that such variations may not only be due to individual variation, but also to accidental effects caused by the preservation and treatment of specimens. Thus, GURNEY's figures, though probably serviceable in the case of foreign species, are of less

importance than one might expect in the systematic determination of Japanese specimens.

b. *MUSCULAR SYSTEM* (Pl. V., fig. 10).

The muscular system of the larva of the present species is, essentially, almost similar to that of the house-fly, described and figured by HEWITT (14, p. 120) in his "House-Fly." In our species, it "consists of a segmental series of regularly repeated cutaneous muscles, forming an almost continuous sheath beneath the skin, together with a set of muscles in the anterior segments of the body which control the cephalo-pharyngeal sclerites and pharynx. In addition to this there are a set of cardiac muscles and the muscles of the alimentary tract." The muscular arrangement of the body wall is, as can be seen from Pl. V., fig. 10, in the fourth to the eleventh segments almost similar, and in the second, third and twelfth more or less modified. I here describe, as an example, the muscular arrangement of the seventh segment: The most prominent muscles are five external (*ex. d. l.*), and five internal (*in. d. l.*), dorso-lateral oblique recti-muscles. Ventral to these muscles (externally situated in the figure), there are three longitudinal ventro-lateral muscles (*l. v. l.*), and still ventral to it there are some ventral oblique muscles (*v.o.*). On the anterior and posterior borders of the segment respectively, there lies a rather stout transverse muscle known as the lateral intersegmental muscle (*l. i. m.*), each of which is connected with an oblique muscle called the internal lateral oblique muscle (*i. l. o.*). The similarity to, and the modification from, this typical arrangement in the remaining segments, may easily be seen in the figure. Between the fourth and the fifth segment, the lateral intersegmental muscles are concealed under the dorso-lateral oblique muscles, the position of which is indicated by dotted lines in the figure.

c. *RESPIRATORY SYSTEM* (Pl. V., figs. 12, 13 in part).

In the adult larva, there is a main tracheal trunk (fig. 12, *m. t. tr.*) on each side in the body, commencing anteriorly at the anterior spiracle, running longitudinally and ending posteriorly at the posterior spiracle. In

the third segment there is the anterior large tracheal commissure (*a. l. t. c.*) that connects the right and left tracheal trunks. Posterior to this is another thin commissure (*a. s. t. c*). In the house-fly, it is said that, near the posterior spiracles, another commissure termed the posterior tracheal commissure is present, though I could not discover this in the present species. From the main tracheal trunks, many branches are sent, most of which are supplied to the border of each segment. Concerning the anterior and the posterior spiracles, explanation is already made under the heading of "external structure of the larva." The five tracheal branches arising from the brain will be described in the next chapter.

d. *NERVOUS SYSTEM* (Pl. V., fig. 11).

The central nervous system of the larva is quite different from that of larvae of other orders, as, for example, the caterpillar. While in the latter, besides the brain, there are many separated thoracic and abdominal ganglia, in the present species, they all together with the brain seem to constitute a single ganglionic mass, being themselves fused together. The mass lies between the third and fourth segment and is composed of the anteriorly situated portion, corresponding to the brain, of which the so-called "cerebral lobes"[1] are seen as paired spherical lobes (*c. l.*), and the posteriorly situated portion, which is a longitudinal rectangular oval body (*gl. m.*) and is known to be made by the fusion of the ganglia of the body segments. From the posterior part of the latter portion many nerves arise in pairs (I could count seven pairs, but the actual number must be still greater), each pair ending respectively at the posterior border of each segment of the fourth to the tenth segment. Besides these nerves, many pairs of fine tracheal branches also arise from the same portion, each ending respectively at the posterior border of the fifth to the eleventh segment.

e. *ALIMENTARY SYSTEM* (Pl. V., fig. 9).

The alimentary canal is much longer than the length of the body, so

1. HEWITT (14) p. 129.

that a certain portion of it is much convoluted. The foremost dilated portion is called the pharynx (*ph.*), which posteriorly narrows into a simple tube of uniform caliber known as the oesophagus (*oe.*). The oesophagus leads abruptly into a round sac termed the proventriculus (*pv.*), posteriorly from which arise four tubular blind sacs known as the caeca (*c. v.*). At the portion behind the origin of the caeca, the alimentary canal is more or less constricted and then becomes a simple tube of rather large caliber known as the ventriculus (*ven.*). The anterior portion of it is usually rather dilated and straight, while the posterior portion together with the distal portion of the alimentary canal called the intestine (*int.*) are much convoluted and twisted. From the junction of the ventriculus and the intestine, the Malpighian tubes (*m. t.*) which are paired ducts arise, each is bifurcate a short distance from the origin, convoluting and mingling with fat bodies and the alimentary canal. The tubes are moniliform in appearance and yellowish in colour. The salivary glands (*s. g.*) consist of a pair of long tubes of rather large caliber, stretching laterally and posteriorly from the fifth to the seventh segment.[1] From the anterior end of each tube a narrow duct arises, each of which joins anteriorly at the posterior border of the third segment (not without exception), running forward as a single median duct and opening into the pharynx on its ventral side.

Fat-bodies[2] consist, as in other insects, of many fat-cells, almost similar in structure to those of the adult flies. Amongst them is a pair of white glandular bodies containing white granular fluid.

6. Pupa (Pl. IV., figs. 5–11).

The puparium (figs. 5–8) is elliptical in form, about 10 mm. in length and 4 mm. in width, composed of eleven segments, a little more convex on the dorsal side than on the ventral, and ochreous in colour. The anterior spiracles appear as paired crescentic tubercles on the anterior extremity (see figs. 6, 7, *a. sp.*) and the posterior spiracles appear as a paired button-like

1. In some specimens, this is not quite fixed.
2. For convenience, I append here a description of the fat-bodies.

prominence on the posterior extremity, with an external structure like that of the larval spiracles (see fig. 8, *p. sp.*). Ventral to the posterior spiracles lies a rhombic piceous shield with the median groove, which is the remnant of the anus.

As far as I could observe, until seven days after pupation there is no superficial development on the pupal body (found within the puparium), although it may appear rather soon afterwards,[1] as is figured in figs. 9 and 10. This state seems to be continued for quite a long time before the emergence of the fly. The pupa bears the paired knob-like processus termed the spiracular processus (fig. 10. *sp. p*), which is destined to constitute the future thoracic spiracles, and is said in the house-fly to communicate with the external air by means of the terminal pupal spiracles between the fifth and sixth segment.

In the pupal stage the external sexual characteristics are differentiated. As in figs. 10 and 11, in the female the extremity of the abdomen is protruded into a conical tubercle, the *anlage* of the future ovipositor, while in the male, the same position is hollowed within, where in the adult the genitalia are found.

IV. LIFE-HISTORY AND HABITS.

1. Time of Appearance.

The time of the first appearance of adult flies in the year varies according to temperature, humidity and many other conditions. Usually, however, it appears at the end of June and accelerates in emergence during July, the maximum emergence being usually reached in this month. Almost the same vigorous appearance may be seen early in August, diminishing towards the end of the month. At the beginning of September in certain localities or under some climatic conditions, the appearance is maintained to a certain extent, until it ceases entirely at the close of the month, although in warm years some flies are often still found in the month of October.

1. Unfortunately I could not ascertain the exact time it requires to make the development, though it seems to be two or three weeks after pupation.

At the first period of appearance males are far more numerous than females, while later in the season females are more prevalent. Observation on confined specimens does not differ essentially from that on those from the open field.[1]

2. Longevity.

It is almost impossible to determine the longevity of the fly in the open field and the observation on confined specimens cannot be considered the same as in nature. Moreover, even in the experiments on the latter, I could not obtain satisfactory results. In my experiments at Tsugumi, of 10 males and 14 females, captured in orchards on July 24, 1914, and kept in captivity, all had died except one female by the 30th of the month although supplied with plenty of food, and the surviving female only lived until the 1st of August, the 8th day after confinement. This was far shorter than I expected, allowing for the fact that the flies lived some days before being captured. In other cases, I could keep flies alive only five days after their emergence in my breeding cage. I am satisfied that these results are not due to any lack of care in keeping the flies alive in captivity, since with the same care I repeatedly succeeded in keeping some other allied fruit-flies in the cage for over one month. Possibly the present species may become much weaker under confinement than when in the open field. Nevertheless, during captivity copulation and egg-laying were undisturbed. Putting these results and occasional out-of-door observations together I conclude that even in nature the present fly does not live longer than one month.

3. General Behaviour of the Adult Fly.

Adults are rather sluggish and calm in habits; they usually rest on the under surface of orange-leaves, stretching out their wings obliquo-

1. Brittain (6, p. 19) writes in *Rhagoletis pomonella* Walsh on the difference of the relative number of males and females, and states that opposite results are obtained from field- and cage-observations. However, he did not mention the variability of the ratio occurring in the earlier and later seasons as in the present species. Back and Pemberton (3, p. 22) write that in *Dacus cucurbitae* Coquillett. the numbers in the sexes are quite evenly divided.

posteriorly as many other flies do. But when they feel themselves quite safe they extend their wings laterally, so that the axes of both wings become almost straight. When, however, they fear some danger approaching, as well as before flight, they restore their wings to the former position. When the flies are slightly disturbed, they simply remove to the neighbouring leaves or branches and occasionally return to the same spot shortly afterwards, but if they are much disturbed, they usually dart away upward or leave the place entirely, sometimes making a long flight. Flies are often seen fighting each other with their heads as weapons. This occurs not only between the same sexes but also amongst different ones. It is not seldom that the males are totally defeated in the action. The flies invariably prefer shady places,[1] so that we can seldom capture them on the parts of trees exposed to the sunshine. For this reason, in the invaded localities experienced orchardists capture flies at noon of a sunny day, since at that time shadows of trees are diminished to a minimum, so that the flies are naturally concentrated in a smaller area. Flies are usually found in thickly wooded places with rich foliage, and for this reason they are abundantly seen at places where old orange trees are planted thickly or other densely-leaved trees interspersed with orange-trees, but are very rarely seen in orchards where comparatively young trees are planted separately, especially where the orchards are exposed to a strong wind.

4. Feeding Habits.

I have often observed, in the open, that flies touched with their proboscis the orange or leaf on which they were resting. Probably, in this way they feed on dew or other substances found on the surface of these objects. Especially at the time when females make punctures in oranges, many flies (mostly males) gather on these infested fruits, possibly attracted by the smell of juice that is secreted from the wounds. Whether flies are fond of the juice or not I cannot say definitely, yet they are not infrequently seen devouring it eagerly.

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1. Severin, H. P. writes in his interesting paper (31, p. 210) that *Epochra canadensis* Loew also seeks shady places.

In breeding cages, during the month of August 1915 and 1916, I tried many experiments in order to test their feeding habits. I offered the flies pear, peach, plum (*Sumomo*), persimmon and water-melon, which were obtainable at that time. These were given both whole and cut, some being put at the bottom of the cage and some hanging from the top. Of these, all the whole fruits placed at the bottom of the cage were left almost untouched. The cut pieces at the bottom were eaten to a certain extent, but the pieces hanging were most attractive to the flies, for a number of them immediately gathered upon the baits as soon as they were put into the cage. Of the above mentioned fruits, the peach seemed to be most appreciated. I also gave the flies some cakes that were likewise eaten, of which the "*An*" (bean-jam) was most preferred. Some of the flies while feeding rested on the same spot for over half a day.

In addition, I gave the flies the liquids mentioned below, which were put into glass vessels hanging from the top of the breeding cage. The results are as follows:

(*a*) *Citronella Oil.* This oil is very attractive to the fly, as it is to other species, *Dacus ferrugineus* Fabricius,[1] *Dacus diversus* Coquillett and *Dacus zonatus* Saunders[2]; the results of an experiment conducted in July and in August, 1915, are tabulated below:

Table II.

EXPERIMENT WITH CITRONELLA OIL TO ATTRACT THE FLY.

Date.	Time.	Hours.	No. of flies.	No. of flies which plunged into the oil.
July 24, 1915	8 a.m.— 5 p.m	9	30	2♂
„ 26, „	1 p m— 5 p.m	4	24	2♀
„ 26–27 „	1 p.m— 8 a.m	19	24	1♂, 7♀
Aug. 1, „	2 p.m— 9 p.m	7	60	3♂, 4♀
„ 2, „	8 a m—12 a.m	4	50	3♂, 3♀
„ 9, „	8 a.m—9.5 a.m	1.5	50	1♂, 2♀

1. FROGGATT (10).
2. HOWLETT (15).
3. I endeavoured to obtain an equal number of males and females, but this could not effectually be done.

(*b*) *Kerosene.* Kerosene seems not so attractive to the present species, although it is not altogether neglected. On July 26, in an experiment with 30 flies during two hours (3 p.m.—5 p.m.), one male and one female only were attracted. It is very noticeable that in this case the female was attracted. Of the Mediterranean fruit-fly females are not usually attracted by kerosene.[1] In a field experiment with kerosene, I fastened a shallow pan filled with kerosene to a branch of an orange-tree, both at Nakada and Seko, where flies were found in abundance. The two pans were kept there from July 28th to 30th, but no flies were caught.

(*c*) *Raspberry Syrup.*[2] This syrup is very attractive to the fly as the following results show:

Table III.

EXPERIMENT WITH RASPBERRY SYRUP TO ATTRACT THE FLY.

Date.	Time.	Hours.	No. of flies.	No. of flies which plunged into the syrup
Aug. 7	5 p.m— 6 p.m	1	29	8 ♀
„ 8	9 p.m—10 p.m	1	26	3 ♂, 3 ♀
„ 9	8 p.m—9.5 p.m	1.5	20	3 ♀

5. DISPERSION.

From the results of my field observations I conclude that the present fly, like the apple-maggot fly,[3] seems to "remain in the immediate locality where emergence took place," and, of course, there is no necessity for migration if there be food-supply at hand and the place is fitted for breeding. For this reason, we frequently find a considerable number of the present species in some orchards of the invaded district, even though neighbouring orchards are often comparatively free.

1. SEVERIN, H. P. and SEVERIN, H. C. (29, p. 225) (28, p. 347).
2. I used a kind of drink sold as the "Ribbon Raspberry" in the market; *vid.* p. 104.
3. O'KANE (25, p. 54); BRITTAIN (6, p. 21).

How the fruit-flies spread from the infested to the uninjured orchards is a difficult question which cannot be readily answered. However, the migration of the flies and the transportation of infected fruits should be considered as principal factors. In order to solve the former problem, a study of the flying habits of the insect is necessary. On this subject (of the fruit-flies as well as of other flies) some papers have already been published. Dr. H. H. P. SEVERIN's paper (27), possibly one of the most recent works on the subject, reports that two thousand Mediterranean fruit-flies, marked by cutting the legs through the tibial portion, were caught during one month by fifty kerosene traps at distances varying from a quarter to one and a half miles from their point of liberation. In his latest work on the currant fruit-fly (*Epochra canadensis* Loew) (31, p. 214) records the results of four experiments, of which the furthest distance that was travelled by two flies out of 150 during June 13–18, was 3290 feet. I made a similar experiment in 1915 at Tsugumi Village, where the present fruit-flies are abundant, but instead of using kerosene traps to capture the flies I had to rely on catching them by hand since kerosene is not attractive to this species. In this experiment, I utilized the days when all the fruit growers of the village are compelled by Order of the District to capture flies. At Chōkō (長幸), which is nearly the middle of the village, high and open, I liberated 102 flies which had been previously captured from orchards on the same day that the experiment was made. Holding each fly in my fingers I cut through the middle of the tibia of one of its legs with a small pair of sharp scissors. The results obtained are as follows.

Table IV.

DISPERSION OF FLIES.

Date of experiment.	No. of flies liberated.	Incision.	Weather and wind.	Date flies were captured.	Flies captured.	Probable distance from the point of liberation.
July 27, 2.10 p.m	26 ♂, 35 ♀	Right mid-leg cut	Weather fine with SE breeze	July 29 Aug. 1	1 ♂ 1 ♀	720 yards
July 29, 2 p.m	20 ♂, 21 ♀	Left mid-leg cut	Weather fine, no wind	Aug. 2 Aug. 3	1 ♀ 1 ♀	480 yards 360 yards

Thus the maximum distance travelled was 6 *chō*[1] (720 yards) and the minimum 3 *chō* (360 yards). These distances are very short, and although we cannot draw any absolute conclusions from so few experiments, yet supported by my field observations, I conclude, that our fruit-fly does not travel far, at least under normal conditions. This is of great importance in considering the control of the adult flies. Of course, if the flight is conjoined with a prevailing wind, the fly may be carried to some considerable distance, as is often the case with the house-fly.[2]

The Tsugumi Village, it is said that the place called Nishinouchi is the central locality where the fruit-flies made their first appearance and whence afterwards they were dispersed through two routes to adjacent places. The one route (Pl. VI., fig. 1) is over the centre of a mountain range, where the orange-orchards are extended continuously from one side to the opposite side of the mountain which belongs to Aoye Village. Formerly people of the village when working on the other side of the mountain gathered the first ripe oranges and either ate them on the spot or took them home. Naturally when they found maggots in the fruit, they threw the infested parts away. Such is the explanation given by the villagers themselves and in later years similar infested oranges have been found in the village itself.

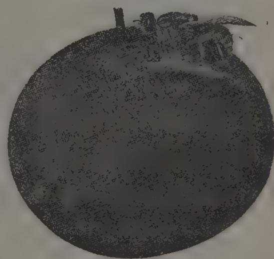
The other route (Pl. VI., fig. 2) is rather remote from Nishinouchi. It is a mountain-pass called Motogoye, where orange-orchards are found on both sides of the mountain, so closely situated that only a short distance to the top of the mountain remains unplanted. It is said that formerly the fruit-fly infestation was only found on the Tsugumi Village side, later it spread to the opposite side. As there is a small path across that place it is more likely that people have picked infested fruits and taken them to the opposite side.

This—transportation of maggots by man—may be one of the chief factors for the fly dispersion, but we cannot exclude from our consideration the flight of the adults; probably both have contributed to the spread of the present fly injuries.

1. A *chō* = *ca.* 120 yards.
2. HEWITT (14, p. 74,—HODGE's result).

6. Copulation.

At copulation, the male embraces the anterior portion of the abdomen of the female, so that its head comes in contact with the hind margin of the female's scutellum. During copulation, the male draws its haustellum in and out. The paired flies often wander about in this state. The flies under copulation are often disturbed by other male, or sometimes female, flies, which swarm around them, their proboscides being used as weapons, and not infrequently another copulation is affected by the new successful rival. The duration of copulations observed by me were as follows:



Text-fig. 2.
Copulation of *Dacus tsuneonis* Miyake. Slightly magnified.

Table V.

Duration of Copulation.

Date.	Time.	Duration.	
July 27, 1915	* 10.40 a.m—10.54 a.m	14 minutes	Average 10 minutes
„ 29, „	† 7 p.m—7.10 p.m	10 „	
„ 29, „	† 2 p.m—2.5 p.m	5 „	
„ 30, „	† 8.53 p.m—9.3 p.m	10 „	
Aug. 1, „	† 8 a.m—8.10 a.m	10 „	

* In the open.
† In confinement.

Copulation occurs at any time in the day, as is the case with the Mediterranean fruit-fly, unlike some foreign fruit-flies, such as the melon-fly (*Dacus cucurbitae* Coquillett), of which it is reported that copulation extends only from sunset to dark.[1] Rather frequently another male tries to copulate with a female already engaged in pairing with a male, keeping its

1. Back and Pemberton (3, p. 23). In their former paper they also state the same fact.

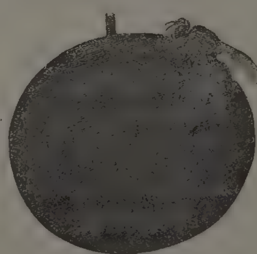
genitalia firmly in contact with the conjugated portion of the two flies. In certain cases, the intruder calmly retains this attitude, until he finally finds out that he cannot join in the act and flies away. Two cases I have seen are as follows:

On July 31, the act lasted from 1.47 p.m to 1.51 p.m......4 minutes
On Aug. 1, „ 12.4 p.m to 12.7 p.m......3 minutes

Not infrequently a female, just after pairing with a male, instantly joins with another male.[1] In a case observed on July 31, the former copulation lasted one minute (1.51 p.m—1.52 p.m.) and the latter 23 minutes (1.52 p.m—2.15 p.m.). When the two flies in copulation are ready to part from each other, the male dismounts from the shoulder of the female, being still connected with the latter and turns its body until the two insects' heads are directly opposite each other. The ∽-shaped coiled organ of the male is first extended to its full length, the terminal end of which is still joined to the female's body and shortly afterwards the connection is broken.

7. Egg-Laying.

The egg-laying habits of the fly were repeatedly observed both in the open and in confinement. When a fly attempts to deposit eggs, it first runs about the surface of the fruit, as if searching for a suitable place. If the place is found, the fly extends its ovipositor full length and then bends it forward so that it makes a rather acute angle with the axis of the abdomen. The sharp point of the ovipositor is then thrust through the skin of the orange. If this is effected, the fly endeavours to penetrate deeply into the fruit, moving up and down, until the desired depth (usually, just beyond the length of the last segment of the ovipositor) is finally attained. This length is just enough to reach the pulp under the skin so that eggs are laid into juice sacs or between them, or in rare cases, between the pulp



Text-fig. 3.

Female fly laying eggs into the mandarin. Slightly magnified.

2. Back and Pemberton (3, p. 23) mention the same fact in *Dacus cucrubitae* Coquillett.

and the rind, but I have never seen them laid in the rind itself. In this respect there is a marked difference in the Mediterranean fruit-fly (*Ceratitis capitata* Wiedemann), of which it is reported that its eggs are very seldom laid in the pulp,[1] and in that in the few exceptions which occur because the rind of the fruit is very thin, they are "subjected to a mortality caused either by excessive moisture or lack of air."[2] The above stated egg-laying habit will explain why only thin-skinned oranges (mandarins and kumquarts) are infested, and thick-skinned oranges (navel oranges,[3] pomelos, etc.) are exempt from the attack of the present fly. And of mandarins, the so-called "*Komikan*" (smaller varieties) is subjected to the attack more severely than the *Unshiu.*

The oviposition may take only a few minutes if circumstances are quite favourable, but the time of duration is very indefinite, as in some cases the action is immediately stopped without any eggs being laid. When the laying is ended, the fly withdraws the ovipositor and walks around the puncture, cleaning the ovipositor with its hind legs. Not infrequently, the fly turns round and feeds on the juice that flows from the puncture. Very probably, the smell of the juice attracts males, because when punctures are made males are often seen to assemble there for the juice. Copulation repeatedly takes place at this time. Occasionally, a male tries to disturb a female engaged in ovipositing, and if he succeeds, copulation usually results.

a. *EGG-PUNCTURE.*

Punctures, known as the "egg-puncture," made by the ovipositor on the fruit, are very small and hardly visible to the naked eye; they are oval or circular in outline, the margin afterwards becoming whitish. The aperture is not infrequently repaired by a brownish gummy substance secreted by the orange. On examining infested oranges brought from orchards of various localities, I found that a single puncture in each fruit

1. QUAYL (26, p. 6).
2. BACK and PEMBERTON (1, p. 318).
3. It was once reported that eggs were laid into the navel oranges, but this is doubtful.

was the most frequent. Occasionally I have found fruit with two punctures, but only one fruit with three punctures and none with more. The instance of a fruit with four punctures was once reported to me. In my experiments on confined specimens, however, one or more flies would attack a single fruit repeatedly, so that those with two or three punctures were more commonly found, though fruits with a single puncture were not rare. I even found some fruits with five punctures, though I could not find any with more. Punctures are made indiscriminately in any part of the orange. The passage of the egg-puncture in the spongy-layer of rind is usually oblique.

Number of Eggs laid in a Puncture. As a single larva appears in each puncture, our entomologists, who have hitherto studied the present species, thought that only a single egg was laid in each puncture. However, in my breeding experiments as well as in field observations, I met no case in which a single egg was present in the puncture, though I have occasionally seen some empty punctures.[1] My observation at Tsugumi Village is as follows:

Table VI.

NUMBER OF EGGS IN THE PUNCTURE.

Date.	No. of eggs in each puncture.		Source of specimens.
Aug. 2, 1915	2		Field
" 3, "	2		"
" 4, "	3		"
" 4, "	4		In-door (breeding cage)
" 5, "	2	Punctures found in a single orange	"
" " "	4		"
" " "	5		"
" " "	4	"	"
" " "	5		"
" 6, "	3	"	"
" " "	6		"

1. Recently FUKAI, Assistant in the Agricultural Institute of Ōita Prefecture, an enthusiastic observer of the present fly, told me that he had seen in one case a single egg in one puncture, although he always used to find more than one in the other cases.

As is seen from the table the maximum number of eggs found in the puncture is six and the minimum two. This differs from that of the Mediterranean fruit-fly, of which BACK and PEMBERTON (1, p. 315) describe 8–153 eggs in one puncture and FRENCH (9, p. 7) reports 5–15 eggs in each fruit.

The fly not infrequently lays eggs on the surface of the fruit, or on a leaf or twig, or occasionally on other substances. From experiments in the breeding cage, when about 30 flies were confined for a week (Aug. 1—Aug. 7), I saw that 7 batches of eggs were laid on the screen of the cage, each batch containing 1, 1, 2, 2, 3, 4 and 6 eggs respectively. As far as I could observe, all eggs that were not laid in the fruit did not hatch out.

b. *EGG-LAYING PERIOD.*

It is a known fact, that in the adults of some exotic fruit-flies the ovarian eggs require some days after emergence before they are fully matured. As for example, in the Mediterranean fruit-fly 6 to 8 days[1], in the apple-maggot fly one week or less[2] or two weeks[3] are required. In my investigation on the present species I dissected some female flies in successive days after emergence (in July), and I observed that the eggs were not much developed until the 5th day. Unfortunately I could not continue the experiment further to discover when they fully develop. However, on examining many specimens captured in the open at the beginning of July, 1915, I could hardly find any which had matured eggs, whence, as is mentioned before, copulation taking place at the end of July and eggs being already laid at the beginning of August, it is very probable that our fruit-fly does not sexually mature until at least ten days after emergence. Anyhow this point requires further study.

It is noticeable that, in these flies, the number of matured eggs differs in the right and the left ovaries. Presuming that the fly oviposites at most 6 eggs in a puncture as long as the matured eggs are numerous in

1. BACK and PEMBERTON (2, p. 367).
2. O'KANE (25. p. 45).
3. ILLINGWORTH (16, p. 144).

the ovaries, it may make several punctures in succession and should lay eggs continuously in the respective punctures. However this point also requires further study.

8. Infestation of Fruits.

a. *HATCHING OF EGGS.*

When the eggs are laid in the puncture, after some days they hatch. How many days they require until they hatch I do not yet know. I observed that eggs laid on Aug. 2, 1915, did not hatch until the eighth or ninth day after the deposition. In exotic species, as for example in the Mediterranean fruit-fly (*Ceratitis capitata* Wiedemann), eggs hatch in warm weather in about two days,[1] in the apple-maggot fly (*Rhagoletis pomonella* Walsh) in five days,[2] and in the currant fruit-fly (*Epochra canadensis* Loew) in 4–7 days.[3] Of course the length of the egg period may be variable according to local and climatic conditions.

b. *MORTALITY OF EGGS LAID IN THE ORANGE.*

As is already stated, usually our fruit-fly lays more than one egg in a single puncture. Nevertheless, when we examine the infested orange, we always find a single larva in the carpel where a puncture has been made. We often find that an orange which bears punctures contains no larva. In a word, though the fly lays a certain number of eggs in the orange, not more than one larva ever appears in each puncture. Undoubtedly some mortality must take place among the deposited eggs of our fruit-fly as is the case in some exotic flies. This mortality of eggs has already been mentioned and discussed by many authors, *e. g.* Back and Pemberton who report in detail on the Mediterranean fruit-fly (1, pp. 315–319). The cause of this mortality in our species is not clear, and as the ovipositing habits of this species differ from those of the Mediterranean fruit-fly it cannot be considered as being due to the same cause—the effect of the oil of the orange rind—as the authors describe regarding the latter

1. Back and Pemberton (2, p. 373).
2. O'Kane (25, p. 60).
3. Severin, H. P. (31, p. 185).

species. However, the same authors treat of the case of the Mediterranean fruit fly with the Chinese orange, in which the cause of death is attributed to excessive moisture or lack of air. In our species, it would seem that lack of air should also be considered as one of the main causes of mortality.[1]

c. *APPEARANCE OF LARVAE.*

The maggots appear (within fruits) usually at the beginning of October. At this time they are very small and measure about 1.5 mm. At the end of the month or the beginning of November, they are usually full grown and attain a length of about 13 mm. The larva, burying itself in the pulp, feeds on juice sacs.

d. *SYMPTOMS OF INFESTATION.*

At the season when the oviposition of the fly is made in the oranges the fruits are still unripe and look totally green. When a puncture is made on the mandarin, sooner or later (three days, according to my investigation in one case), a certain portion of the rind around the puncture becomes slightly paler than the ground colour. Day by day this pale-coloured portion becomes more and more yellowish and ochreous, stretching out gradually until it occupies a considerable area of the rind. Still later this coloured area becomes slightly reddish, usually appearing longitudinally but sometimes circularly or irregularly, along the carpel within which is the maggot. In this way, we can very easily detect the infested fruits in the invaded locality in the middle of October,[2] the time best fitted for recognizing injured fruits. With kumquarts the case is not alike ; in that fruit, the punctured portion remains dark greenish like the ground colour, though the external area around the puncture is usually coloured yellowish as in other infested mandarin oranges. In the infested

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1. Recently SEVERIN H. P. in *Epochra canadensis* Loew, and BRITTAIN in *Rhagoletis pomonella* Walsh also described the mortality of eggs, the cause of which is unknown.

2. There may be some fluctuation according to yearly climatic variations. In warmer seasons this symptom may typically appear at the end of October, while in colder seasons it may occur at the beginning of the month.

kumquart this yellowish area afterwards becomes broader but never fulvous as in the mandarin oranges.[1]

If we examine the pulp of the infested orange, the carpel which is affected by the maggot appears quite different from the other uninjured carpels, presenting a sooty unpleasant yellow in contrast to the bright ochreous colour of the sound carpels. The carpel in which the maggot makes its first appearance becomes shortly afterwards narrower and thinner than the other carpels. This can be seen very clearly in the cross section of the fruit (Pl. VII., figs. 1, 2, 3 Pl. VIII., figs. 1, 2). As mentioned before, a single maggot appears within each puncture, although many eggs may be laid in it and though this may be due to the moratlity of the deposited eggs in some cases, yet the mortality of the newly hatched larvae must also be taken into consideration, for I have occasionally found a small dead larva in the infested carpel along with the living one. This mortality of the larvae in our species is much rarer than in the Mediterranean fruit-fly and some other exotic species, of which we are informed that this is a normal occurrence.[2]

By far the majority of injured mandarin oranges, which I have examined, have had only one originally infested carpel, *i.e.* the orange contains only one maggot, although the adjoining carpels may be subsequently infested by the same maggot (Pl. VII., figs. 1, 2, 3 ; Pl. VIII., figs. 1, 2). Instances of two originally infested carpels are not extremely rare. In this case, each infested carpel is well separated from the other[3] (Pl. VII., figs. 4, 5, Pl. VIII., figs. 3, 4)—usually opposite (Pl. VII., figs. 5., Pl. VIII., figs. 3). If the two maggots found in such an orange are not equally developed, the one is often much smaller than the other. Very seldom three carpels are infested (Pl. VII., figs. 6) and a case of four infested carpels has only once

1. I have, however, in 1917, in Higashi-morokata District, Miyazaki Profecture, observed the same feature in the kumquart as in the mandarin. This might possibly be due to the varietal difference, as the former observation was made on "*Marumi*" kumquart, while the latter on "*Nagami*" kumquart.

2. The authors quoted in p. 127 have also mentioned the mortality of larvae as well as of eggs.

3. Rarely without exception. As shown in Pl. VII., fig. 9, the originally infested carpels are situated at right angles to each other.

been reported. No case of more than four infested carpels has yet been found.

The reddish yellow area of the infested oranges extends, in the later stage, wider towards the periphery and at this period (the beginning or middle of November), the entire rind of the orange itself begins to turn yellow, so that we can no longer distinguish at a glance the infested fruit from the sound. However, if we closely examine the infested orange, there is usually a more reddish tinge on the oviposited part, moreover, in the later stage, the portion around the calyx also becomes reddish. The infested orange can be also detected by the presence of the puncture, which may often be seen by the naked eye.

When the larva has nearly eaten up the contents of one carpel, in which it made its first appearance, it removes to the adjoining carpel, boring through the intermediate septa (Pl. VII., figs. 5, 6; Pl. VIII., fig. 4). Usually, until a maggot fully develops, still another and sometimes more carpels are attacked, according to the size of the fruit, the activity of the larva and to the duration of the larval period (Pl. VII., figs. 7, 8). When more carpels are infested their contents are only partly eaten. Speaking generally, if the carpel of the orange is sufficient for the nutrition of the whole larval life, only one or two carpels may be infested, although exceptions not infrequently occur. In other cases, however, as many as ten carpels may be injured as is shown below. In the kumquart, in which the sectioning is more imperfect than in the mandarin oranges, the maggot pierces the pulp quite irregularly and usually eats the seeds contained, and as the fruit is smaller I have never found in it more than one maggot (Pl. VIII., figs. 5, 6, 7, 8).

Table VII.

NUMBER OF INFESTED AND NON-INFESTED CARPELS IN AN ORANGE.

OBSERVED IN *Zemmon*, DEC. 14, 1915.

No. of oranges tested.	No. of non-infested carpels.	No. of infested carpels.	Larvae present or issued.
1	10	3	Present
2	10	3	Issued
3	9	2	"
4	10	2	"
5	8	3	"
6	9	3	"

OBSERVED IN *Komikan*, DEC. 15, 1915.

No. of oranges tested.	No. of non-infested carpels.	No. of infested carpels.	Larvae present or issued.
1	11	5	Issued
2	10	5	"
3	11	7	"
4	9	4	"
5	9	6	"
6	10	4	"
7	11	10	"
8	11	10	"
9	10	4	"
10	9	7	[illegible]

The percentage of infested fruits in a single tree is not fixed, owing to local, annual and individual differences. When the appearance of the fly is vigorous, it is often reported to amount to 40% or 50% of the total fruit of a tree. Some examples, observed by OJIMA of our Entomological Division, at Obama Village, Tamana District, Kumamoto Prefecture, are tabulated as follows:

Table VIII.

PERCENTAGE OF INFESTED FRUITS IN A SINGLE TREE.

Date.	Kind of fruit.	Total number of fruit obtained from a single tree.	No. of infested fruit.	Percentage.
Nov. 1, 1909	*Komikan*	1219	294	24%
"	"	1000	241	24%
Dec. 4, 1909	"	100 nearly	63	63%
"	"	100 nearly	6	6%
Dec. 4, 1910	"	1300 nearly	48	3.6%
"	*Unshiu*	590	21	3.5%
Dec. 21, 1910	*Komikan*	794	98	12.3%
"	*Unshiu*	522	46	8.8%

e. *EXIT OF LARVAE FROM INFESTED FRUITS.*

When the larva in the orange is fully developed, sooner or later the infested fruit falls to the ground. The falling of fruits begins in the month of October and continues to November. Shortly after the fruit has fallen, the issuance of the larva takes place. This may occur within a few hours or after one day or more. Occasionally, however, larvae issue from oranges still on the tree. For this reason, infested oranges freshly picked from trees do not always bear larvae, though this may partly be due to the mortality of larvae in the fruit.[1] In an observation I found 8 oranges out of 10 free from larvae and in another, 69 out of 168.

In order to get out of the orange, the larva makes a rather large, circular aperture, corresponding to the thickness of its body. Usually the larva issues rather rapidly from the fruit, though not infrequently it may struggle in drawing out its body, only succeeding in coming out half way. As the time in which infested oranges fall happens to be the harvest season, all the fruits are picked and gathered for sale in the growing district, so that infested oranges are usually gathered before they fall,

1. The larva should be considered lost after death.

though some of them may drop previous to the harvest.[1] A great number of infested oranges were repeatedly sent to me for examination and I have observed the under-mentioned facts. Larvae seem to issue both by day and by night, but so far as I observed the issuance was more frequent in the night than in the daytime. I tabulate the observations made by Mr. FUKAI, of the Agricultural Institute of Ōita Prefecture, to whom I am much indebted for valuable assistance given me during my stay a the locality :

Table IX.

COMPARISON OF EXIT OF LARVAE BY DAY AND BY NIGHT.

Description of lot.	Date of daytime issuance.	No. of larvae issuing by day.	Date of the night issuance.	No. of larvae issuing by night.
101 mandarin oranges collected at Yukagi, Tsugumi, Oct. 23, 1915.	8 a.m, 24th—4 p.m, 24th	2	4 p.m, 23rd—8 a.m, 24th	26
	9 a.m, 26th—4 p.m, 26th	1	4 p.m, 24th—9 a.m, 25th	1
	9 a m, 27th—4 p.m, 27th	1	2 p.m, 26th—9 a.m, 27th	0
	9 a.m, 28th—4 p.m, 28th	1	4 p.m, 26th—9 a.m, 27th	26

Larvae appear daily from harvested oranges but some immatured larvae occasionally remain very late in the fruit. I have known them remain for 20 or more days. Some examples observed by FUKAI are tabulated below :

1. At Tsugumi Village, Ōita Prefecture, fruit growers are ordered to pick up infested oranges previous to the harvest season, as soon as the first symptoms of infestation appear.

Table X.

EXIT OF LARVAE FROM PICKED INFESTED FRUITS.

Date picked.	No. of oranges.	Date of issuance.	No. issuing.
Nov. 23, 1914	101	Nov. 24, 1914	28
		25,	2
		26,	1
		27,	28
		28,	22
		29,	1
		30,	0
		Dec. 1,	2
		2,	1
		3,	0
		4,	1
		5,	0
		6,	0
		7,	0
		8,	1
		9,	1
		10,	0
		11,	2
		12,	2
Nov. 27, 1914	163	Nov. 27, 1914	20
		28,	(Record lost)
		29,	40
		30,	3
		Dec. 1,	2
		2,	1
		3,	2
		4,	0
		5,	2
		6,	2
		7,	0
		8,	3
		9,	1
		10,	1
		11,	2
		12,	2
		13,	0
		14,	4

f. *RESISTANCE OF LARVAE.*

The question as to how long the larvae can resist water or chemicals is not only interesting biologically but also very important in its relation to control measures. Speaking generally, the resistance of larvae to either sea- or fresh water is far stronger than one might presume before experiment. An experiment conducted by me is detailed below:

Table XI.

RESISTANCE OF LARVAE TO WATER.

Date.	No. of larvae experimented upon.	Hours submerged.	Kind of water.	Living or dead.
Oct. 22, 1915, 11 a.m—10 p.m	3	11	Sea-water	Living
„ 22,4 p.m—23,7 a.m	15	15	„	„
„ 22,4 p.m—23,8 a.m	15	16	„	„
„ 22,11 a.m—23,8 a.m	3	21	„	„
„ 22,4 p.m—23,8 a.m	9	16	„	„
Nov. 5, 1915, 3.30 p.m—10.10 p.m	10	6.40	Well-water	„
„ 19,4 p.m—20, 10 a.m	3	13	„	„
„	3	13	Alcohol 70%	„

In these experiments, the larvae which were brought out from the water appeared at first to be dead, but sooner or later they recovered. The temperature of the water was usually C.16°.

The larvae when put into sea- or well-water wriggle about at first and afterwards become calm. According to FUKAI's observation, motion ceases at the end of about three and a half hours after submergence, though in reality the maggots are not weakened or killed. The time larvae take to recover from this dead appearance varies, of course, according to the length of time they have been in the water.

FUKAI[1] prolonged the experiment until the larvae were dead. An example is shown in table XII.:

1. Unfortunately FUKAI did not record the temperature of the water.

Table XII.[1]

RESISTANCE OF LARVAE TO WATER.

1. *Experiments in Well-Water with 10 Larvae.*

Date.	12 days submerged.	14 days submerged.	23 days submerged.
Nov. 24, 1915	3 dead	6 dead	1 dead

2. *Experiments in Sea-Water with 10 Larvae.*

Date.	5 days submerged.	6 days submerged.	9 days submerged.
Nov. 24, 1915	1 dead	5 dead	4 dead

Thus larvae submerged in sea-water died after 9 days, but with well-water 23 days were required to kill them all.

FUKAI further experimented as to whether larvae, which have previously been submerged in water, can pupate.

Table XIII.

PUPATION OF LARVAE PREVIOUSLY SUBMERGED IN WATER

(*Experiments conducted on Nov. 6, 1915, each with 5 Larvae.*

Water used.	1 day submerged.		2 days submerged.		3 days submerged.		4 days submerged.		5 days submerged.	
	Pupated[1]	Dead[1]	Pupated	Dead	Pupated	Dead	Pupated	Dead	Pupated	Dead
Well-water	5	0	5	0	5	0	5	0	3	2
Sea-water	4	1	5	0	3	2	4	1	3	2
Lime-water	5	0	4	1	5	0	3	2	3	2

He also examined as to whether these pupae could develop into imagos.

1. The days required for pupation or until death were not recorded.

Table XIV.

EMERGENCE OF IMAGO FROM SUBMERGED LARVAE.

(*Conditions as in Previous Experiment.*)

Water used.	1 day submerged.		2 days submerged.		3 days submerged.		4 days submerged.		5 days submerged.	
	Emerged	Not	Emerged	Not	Emerged	Not	Emerged	Not	Emerged	Not
Well-water	5	0	5	0	3	2	2	3	2	1
Sea-water	3	1	5	0	1	2	4	0	0	3
Lime-water	5	0	0	4	2	3	1	2	0	3

From the above two tables one may see that the larvae can resist well-water longer than sea-or lime-water and that in the latter, pupae 5 days submerged did not develop into imagos. Though we cannot draw any positive conclusion from these experiments, it seems that if larvae are submerged over ten days in sea- or lime-water, or over 24 days in well-water,[1] they are almost sure to die.

Another experiment conducted by FUKAI shows that, if infested fruits that contain larvae are submerged in water, the maggots can resist still longer. FUKAI'S experiment is as follows:

Table XV.

SUBMERGENCE OF INFESTED FRUITS IN WATER DURING TEN DAYS.

(*Dec. 16—26, 1915.*)

Water used.	Fruits submerged.	Larvae contained in the fruits.	Dead or living.
Well-water	26	27	Living
Sea-water	26	29	"
Lime-water	26	29	"

He further experimented as to whether these larvae could pupate.

1. Other fresh water, such as river water etc., can be included.

Table XVI.

PUPATION OF LARVAE IN SUBMERGED INFESTED FRUITS.

Water used.	No. of larvae in infested fruits submerged.	Pupation.	Dead.
Well-water	27	3	24
Sea water	29	9	20
Lime-water	29	6	23

It will be seen that in this experiment more larvae submerged in sea-water pupated than in well-water, in which connection FUKAI suggests that the orange preserves better in sea-water than in well-water so that the larvae in the former can offer a stronger resistance than those in the latter. This, however, requires further study.

9. PUPATION.

Larvae, after issuing from the fruits, crawl about on the surface of the soil for a while and then penetrate into it and begin to pupate.[1] I observed in 1915, that a larva which issued on Nov. 17 pupated on Nov. 23, and another issuing on Nov. 19 pupated on Nov. 22. In some cases, however, the larval stage lasts a comparatively long time (a week or more).

Pupation often takes place inside as well as outside the fruit, on the surface of the soil as well as beneath it. It is daily observed that larvae under experiment pupate easily, without burying themselves, within the vessel that contains them.

Pupation may occur from the end of November till the end of December, or, occasionally, in January of the next year. FUKAI observed in 1915 a pupation as late as Jan. 28.

1. If circumstances are favourable they immediately bury themselves in the ground.

a. *DEPTH LARVAE PENETRATE INTO THE SOIL.*

Larvae do not penetrate deeply into the soil; usually the depth is from one to two inches. FUKAI observed that out of 128 pupae, 115 were within one inch, 11 within 2 inches and 2 within 3 inches. Usually their heads are directed towards the surface of the soil.

10. EMERGENCE OF ADULT FLY.

When the fly is about to emerge it pushes off with its frontal sac (ptilinum) the anterior end of the pupal case. In emergence from the pupal case a horizontal split is formed along the middle of the 4th segment, and a frontal split between the remains of the oral part and the anterior spiracular processes (See Pl. IV., figs. 5, 7, in which the line is indicated) so that, from the top of the case dorsal and ventral triangular chitinous pieces are broken off along these lines, and from the aperture thus made the new fly begins to draw out its imprisoned body. Usually, however, the dorsal triangular piece only breaks off from the pupal case, the ventral one being still attached to the case. The eclosion of the fly from the pupal case is not always easily made. If the pupa is placed on the surface of the earth (or on the bottom of any vessel), as was done in our experiments, the pupal case being unfixed the newly coming fly loses the necessary levering power to bring its body out from the puparium. This being so, of many pupae under my experiment, though some performed the eclosion completely within one hour, a few required a whole day, while some did not succeed in getting out from the puparium even after two days and were dead on the third day. The passage through which the fly comes to the surface of the earth seems, as far as I could observe, to be rather oblique and bent, as for example shown in text-fig. 4.

Text-fig. 4.
Tunnel in the soil made by the fly attempting to come out (June 1, 1916). Natural size

The fly comes to the surface of the earth by means of the inflated ptilinum of its head which it first extrudes and then draws back again, and even after coming to the surface of the earth the fly continues this action for a while. The newly emerged fly, pale in colour, bears folded wings laid on the dorsum of its body, but it has to crawl about for some time until its wings expand and its exoskeleton hardens.

OJIMA tested whether the emergence of the fly could be prevented by burying the pupae deeply into the soil, and obtained the result that burying at a depth of 1.5 feet does not kill the pupae. One of his experiments is reproduced in table XVII.

Table XVII.

EXPERIMENTS IN BURYING PUPAE.

100 Pupae were buried in each Section towards the End of December, 1913.)

Date of emergence.	No. of flies emerged from section 1 (buried 3 inches).		No. of flies emerged from section 2 (buried 5 inches).		No. of flies emerged from section 3 (buried 8 inches).		No. of flies emerged from section 4 (buried 1 ft).		No. of flies emerged from section 5 (buried 1.5 ft).		Total.		
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Both
June 14. 1914		2										2	2
15 ”	2	3							2	2	4	5	9
16 ”	2	2	1	2							3	4	7
17 ”	3	5	1								4	5	9
18 ”	1	1	2	3							3	4	7
20 ”	1		4	6				3			5	9	14
21 ”					4	2	1	1			5	3	8
22 ”			2		6		4	3			12	3	15
23 ”				1	1	2		2			1	5	6
25 ”					2	1	6	6			8	7	15
26 ”							1	2		1	1	3	4
27 ”							5		2	2	7	2	9
29 ”							1	1	1	1	2	2	4
Total.	9	13	10	12	13	5	18	18	5	6	55	54	109
	22		22		18		36		11		109		

11. Life-Cycle.

From the facts above stated, we may conclude that the fly has only one brood in a year; adults appear at the end of June, accelerating in appearance during July, and in August they lay eggs. Larvae appear at the beginning of October and mature in the month of November. Pupation takes place at the end of that month or at the beginning of December, and in the pupal stage they pass the winter under ground until the adult flies appear in the early summer of the next year. The life-cycle is shown in Table XVIII.

Table XVIII.

Life-Cycle of *Dacus tsuneonis* Miyake.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
First year						+	+++	+++ . . .	. . .	— — —	— — •	•••
Second year	•••	•••	•••	•••	•••	••+						

12. Other Insects found in Oranges likely to be mistaken for the Present Species.

In decayed oranges, mostly in those fallen on the ground, occasionally the larvae of *Drosophila* occur (they appear to me to be more than one species). The maggot can easily be distinguished from that of the present species by its peculiar form. It is provided with a bilobed protuberance at the posterior end, on the tip of which the posterior spiracles open. Moreover, the mature maggot of the present species is far larger than the Drosophilid larva.

We often find on trees some pre-ripe oranges which look exactly like infested fruits of our species. The following are the chief causes for their appearance:

1. A wound on the rind, caused either accidentally or by the wind; in these cases there is no egg-puncture.

2. Oranges and other fruits are often sucked by some Noctuid moths, such as *Ophideres tyrannus* Guenée, *Calpe excavata* Butler, etc. If these moths pierce the fruit a small puncture remains on the rind. The orange afterwards decays and falls. The puncture is smaller than the exit-hole, but larger than the egg-puncture of the present species.

3. Some Tortricids[1] and Pyralids (one is *Dichocrocis punctiferalis* Guenée) often bore into oranges. The boring by these insects gives oranges an appearance closely resembling fruit-fly infestation and is therefore very frequently mistaken for the injury caused by this species. Nevertheless, in the case of these Lepidoptera, the larvae that are found in the fruit bear legs peculiar to caterpillars while entrance and exit are usually made through the same aperture. Besides, the burrowing of these Lepidoptera is usually shallower than that of the fruit-fly, often not reaching to the pulp, and where the pulp is reached, only a superficial part is injured. A certain area around the hole made by these Lepidoptera is usually coloured very dark.

V. METHODS OF CONTROL.

1. Natural Enemies.

No parasites have been discovered up to the present, although I have paid special attention to this question. Predaceous insects, such as dragonflies and big Asylids, that are found in the locality, may possibly prey upon the flies, and I have heard from native observers that they occasionally see these insects feeding on the flies. Birds, spiders, ground-beetles and ants may, to a certain extent, take part in destroying them in their various stages, although I have no positive evidence to prove that such is the case. In 1914 and 1915, I experimented as to whether the *Bittacus*, which is known to prey upon the house-fly, might not be utilized in destroying these flies. After repeated trials, however, I discovered that none of the Bittacids would touch the fruit-flies, although under the same

1. According to OJIMA there are two kinds of Tortricids, one of which is identified as *Cacoecia podana* Scopoli.

conditions they were very ferocious in preying on house-flies. Out of a great many specimens of fruit-fly pupae sent from Kita-kata Village, Miyazaki Prefecture, some Tachinid flies emerged, but unfortunately I was not able to make certain whether they had been parasitic upon the fruit-fly pupae or whether they had been accidentully mixed with the pupae of the fruit-flies.

2. Capture of Adult Flies.

The capture of adult flies is probably an effective measure in mitigating the fly-injuries. In Amabe District of Ōita Prefecture, fruit-growers of the invaded villages capture the adult flies, at least five times every season, by Order of the District, the flies being purchased at a price agreed upon for each particular village. According to the agreement these flies are purchased by the various local offices of the invaded villages at a price ranging from 2 *rin* to 5 *sen* each.[1] Thus, for example, at Aoye Village, in 1914, 78351 flies were purchased at a cost of 621.366 *yen*[2], and at Tsugumi Village, 201675 flies for 1016.646 *yen*. The effect of the capture of these flies in reducing the fly-injury must not be underestimated, for in the localites where the capture of flies has been carried out strictly, the number seen has been remarkably reduced, while at distant localities where the capture has been neglected, fruit-flies were seen abundantly in the orchards during the same season.


Text-fig. 5. Apparatus used at Tsugumi Village for catching flies. ×⅛.

In order to capture the adult fly, at Tsugumi Village, a special apparatus, as is shown in text-fig. 5, is used.[3] It is a flat oval iron-framed

1. This difference of price is due to the numbers in which the flies abound and to other local circumtances. 1 *sen*=10 *rin*=½ *d*. Engl. money, or ½ *c*. U.S.A.

2. 1 *yen*=100 *sen*.

3. This was proposed by KUBOTA, an orange-orchardist of Tsugumi Village.

hemp-yarn net of rather coarse meshes with diameters of 130 and 70 mm. This net is attached to the top of a bamboo-rod five feet long. Sometimes another rod of the same length is added to the original rod if it is desired to make the length of the handle longer. Bird-lime is applied to the net in order to capture the flies. At invaded localities of Miyazaki Prefecture simply a bamboo rod is used, with bird-lime on the top. Natives of these localities say the rod is more convenient than the Tsugumi-apparatus for use amidst thick twigs. A skilful hunter, it is said, may catch about 130 flies in a day at Tsugumi Village.

3. Treatment of Infested Fruits and Killing of Larvae and Pupae.

At invaded localities, infested fruits both on trees and on the ground are gathered, in order to kill the larvae contained in them. At Tsugumi Village a specially planned reservoir, made of concrete, is prepared for destroying these maggots. Infested fruits are thrown into it and lime-water is poured upon them, in order to kill the larvae. At certain localities, infested fruits are steamed or burnt by petroleum (*vid.* Pl. IX.). For this purpose infested fruits were also purchased at the local offices of several villages of Kita-amabe District. At some villages of Ōita and Kumamoto Prefectures, infested fruits are sold on the market. In the case of Kumamoto Prefecture, this sale of infested fruits was formerly even encouraged by the village authorities, since those fruits appeared ripe before the uninjured ones, so that the demand of early consumers could be met. The excuse was offered that the larvae that might issue from such fruits could not breed at the place where the oranges are eaten, provided that it is distant from the orchard, so that the fly cannot find any food-plants.

Recently it was thought that, instead of wasting infested oranges, they could be utilised as raw material for the manufacture of citric acid. Accordingly, directions for preparation were issued by the Bureau of Agriculture and this industry generally encouraged by the authorities.

For the purpose of collecting pupae from the ground at Kita-kata Village of Miyazaki Prefecture, the soil is plowed. This is not done at Tsugumi Village, since the roots of the orange-trees are covered with heaps of hay or straw. At places like Kita-kata, the use of poultry, as recommended in several foreign reports for the extermination of the exotic fruit-fly pupae, may, to a certain extent, serve as a check on the flies, so long as the orchard is not too remote from human dwellings. It is reported that poultry are used for this purpose at certain places in Miyazaki Prefecture, but I have not been informed of the results.

4. Other Measures.

Screening of trees, traps, the use of attractive substances (for example—citronella oil), or poison (for example—Mally's fruit-fly remedy[1]) might probably be effective in preventing injuries, but as far as I could see, complicated circumstances in the invaded localities made all these methods most difficult to employ.

5. Recommendations.

I would offer here the following suggestions:

1. Every effort should be made to capture adult flies early in the season of emergence when they do not oviposit in the fruit because their eggs are not yet matured.

2. Infested fruits should be gathered as quickly as possible. To do this, the first slight symptom should be detected, while the fruit is still on the tree. This may prevent the larvae escaping from the fruits; if fruits once fall, some larvae are sure to leave them and enter the ground. Moreover, unripe oranges can better be utilized as material for citric acid than ripe ones.

3. To utilise infested oranges as raw material for citric acid manufacture, since the acid is prepared from oranges by a rather simple chemical process. Thus infested oranges would be taken to a certain spot where the factory is established. In this case the reservoir to be used should be carefully equipped so as to prevent the escape of larvae.

1. Publication of the Department of Agriculture, Cape of Good Hope (7).

4. The construction of storehouses for oranges should be so improved, that if by mistake infested oranges are taken in, the larvae that issue therefrom can be collected at a certain spot where they may easily be killed. For that purpose, on one hand the floor should be firm and without intermission, so as to prevent the larvae from penetrating for pupation, and on the other hand, a certain dark spot should be left where larvae would gather on account of their phototaxis.

5. To diffuse the fullest knowledge of the present species among local orchardists, so that they may at once detect the occurrence of the insect and minimise the injury caused by this species.

VI. DESCRIPTIONS OF NEW SPECIES BELONGING TO TRYPANEIDAE.

The author makes use of this occasion to describe 5 new species which have been discovered in the course of the present study.

1. *DACUS (CHAETODACUS) BEZZII*[1] n. sp.

(Nom. Jap. *Shima-mibai.*)

(Pl. II., fig. 2, ♀; Pl. X., fig. 2,—wing.)

? Dacus trivittatus Matsumura (nec Walker), (22), p. 41, pl. xxiii., fig. 9 (1916).

A medium-sized species; all the bristles are black.

Head greyish ochreous; occiput and posterior portion of the gena sprinkled with fuscous; frons with a central irregular round fuscous patch in the middle (obsolete in some specimens) and four lateral fuscous dots on each side, the anterior two of which are very closely placed. From each lateral dot the front-orbital bristle arises; vertex with a shining black transverse band including the ocellar triangle, which is also black (in some specimens this band is interrupted in the middle); a crescent-shaped

1. Dedicated to Prof. Dr. M. Bezzi of Italy, who has favoured me with most valuable advice in the course of the present study.

fuscous patch on the antennal ridge (lacking in some specimens); eyes reddish brown; clypeus yellow, shining with two round black patches; antennae ochreous, the basal two joints shining ochreous; the third joint greyish ochreous; arista black, yellow at the base; proboscis ochreous yellow, with some fuscous patches at the base of the haustellum, the palpi fuscous ochreous.

Thorax densely punctate, covered with short greyish pubescence; dorsal side greyish black, with a median λ-shaped, and paired submedian, longitudinal black streaks; a median, spindle-shaped greyish-yellow spot bounded by the posterior branches of the λ-shaped streak; humeral calli greyish yellow; a long lunular greyish yellow streak on each side, defined internally with black, commencing anteriorly at the transverse suture and ending at the junction of the scutellum; scutellum greyish yellow with four bristles, the apical part testaceous; (in fresh specimens all the above greyish yellow markings appear greenish yellow and this tinge often remains unchanged in some specimens); median plate of the post-scutellum black; lateral side blackish, except a large patch on the lateral plates of mesosternum and postscutellum, both of which are yellow; halteres yellow; chaetotaxy as in subgenus *Chaetodacus* Bezzi (5, p. 86) with praescutellar, and one anterior, and two posterior supra-alar bristles. Male with the second axillary lobe.

Legs ochreous; coxae testaceous; end of all the femora, base and end of all the tibiae, and distal joints of all the tarsi testaceous; upper side of the hind tibiae in most specimens with testaceous streak.

Wings hyaline; veins fuscous; the costal margin except on the costal and first costal cells narrowly bordered with brown from the pterostigma to the apex, where the brown is widened; a broad brownish suffusion on vein *Cu2.* + 1st *A.* (broader in the male specimen), filling the cubital cell with brown; a brownish suffusion along the median transverse vein.

Abdomen greyish ochreous, oval, as broad as the thorax, the first segment with the basal margin and the lateral sides bordered with black (in some specimens a triangular black patch is present in the middle); the anterior margin of the second, third and fourth segments bordered

with broad black bands; the band of the third segment produced posteriorly into a short triangular projection in the middle; that of the fourth segment also with a median posterior projection, which is longer than the preceding one, so that it represents a T-shaped marking; the anterior margin of the fifth segment also with a broad piceous band, which is broken in the middle, where it is traversed by a median longitudinal band; (in exceptions the fifth or the fourth and fifth segments bear the same T-shaped markings; male with a row of black bristles on the sides of the posterior margin of the third segment; female with the ovipositor rather depressed, ferrugineo-ochreous, the basal joint longer than the fifth segment.

Male. Length of body 7—8 mm.; length of wing 6—7 mm.

Female. Length of body (measured to the origin of the basal segment of the ovipositor) 9 mm.; length of wing 8 mm.

Local Distribution. Ōita, Miyazaki, Kagoshima and Kyoto.

Habitat. Kiushiu and Honshiu.

Described from 5 male and 5 female specimens taken at Tsugumi, on Aug. 28, 1915; besides many others examined.

Abundantly found in orange-orchards, from July to September, occasionally in November and December, but as far as I could observe the fly does not oviposit in the orange nor do adults appear from any of the maggots found in oranges, so that until positive proof has been found, the present species should not be considered as injurious to oranges, though some entomologists suppose them to be dangerous. Moreover, the species occurs in abundance in a locality where no orange trees are planted.

This species, in having three supra-alar and praescutellar bristles, and being indented on the hind margin of the wing at the end of vein *Cu*2. + 1st *A.* (anal of Bezzi, 4) in the male specimen, bears the characteristics of *Chaetodacus* created by Bezzi (5, p. 86), if my conception of the genus is correct.

The present species is closely allied to *Dacus* (*Chaetodacus*) *scutellaris* Bezzi and *D.* (*C.*) *scutellatus* (Hendel). But it differs from both species

in the markings on its abdomen, so that I have described it as a probable new species in my official report on fruit-flies presented to the Imperial Department of Agriculture and Commerce in 1914. Afterwards I sent some specimens of this species to the British Museum for confirmation, whence they were sent to Prof. BEZZI of Italy who noticed that the specimens differed in many characteristics.

The species also differs from *Dacus* (*Chaetodacus?*) *trivittatus* (Walker), especially in the markings on its abdomen, if my conception of the original is correct. However, a specimen contained in the collection of the Hanazono Entomological Laboratory of Kyoto, identified as *Dacus trivittatus* by Prof. MATSUMURA of Sapporo appears to me to be no more than an example of this species. But, the species described and figured as *Dacus trivittatus* in his "Thousand Insects of Japan," Additamenta (22, p. 411, pl. xxiii., fig. 9), differs from the present species in the markings of the abdomen, since none of the abdominal bands of Matsumura's species are produced in the middle, so that the identity of the two species cannot be assumed until a closer observation has been made of the original specimen determined by Prof. MATSUMURA.

In October of last year (1917) I saw, at Tsugumi Village, a number of the flies swarming about some over-ripe persimmons on the trees.

2. *HYPENIDIUM POLYFASCIATUM* n. sp.

(Nom. Jap. *Sesuji-hamadarabai.*)

(Pl. X., fig. 3,—wing.)

Body ochreous, with black streaks; all the bristles are black.

Head ochreous, with the ocellar triangle black; eyes purplish brown; face and genae whitish; antennae deeply ochreous, with the third joint rather short and rounded at the apex; arista shortly pubescent, blackish with the base ochreous; proboscis with the palpi ochreous.

Thorax above ochreous with piceous pubescence; tergal margins and humeral calli fulvous; a pair of black median streaks, ending posteriorly at

the middle of the scutum ; a pair of broader black submedian bands, interrupted at the transverse sutures ; scutellum ochreous with four very long bristles ; median plate of the postscutellum piceous black ; lateral sides and halteres pale ochreous.

Legs pale ochreous.

Wings hyaline, with the costal half fuscous black, with some pale streaks in the cells along the costa ; the posterior limit of the black area with three rounded indentations in the first second medial cell beyond vein *M*1 + 2. and one indentation before the vein in the second second-medial cell ; a narrow black streak, which is continuous with the costal black area, on the median transverse vein.

Abdomen brownish ochreous, coarsely clothed with piceous pubescence ; the base of the first segment black ; second segment with a black transverse streak on each side ; third segment with a broad transverse black band, interrupted at the middle ; the fourth to the sixth segment with very broad black bands, of which the last one is slightly interrupted at the middle ; ventral side ochreous ; ovipositor with the basal segment black, the apical two segments testaceous.

Female. Length of body 6.5 mm. ; length of wing 6.5 mm.

Described from a single female specimen, taken by MITSUHASHI at Kiso-Fukushima, on July 31, 1914.

3. *ACIDIA KAGOSHIMENSIS* n. sp.

(Nom. Jap. *Kagoshima-hamadarabai.*)

(Pl. X., fig. 5,—wing.)

Prevailing colour of the body fusco-ochreous ; all the bristles are black.

Head with the occiput and the vertex fusco-ochreous, the frons yellow ; ocellar triangle black ; eyes purplish ferruginous with greenish black patches ; clypeus whitish ; genae ochreous ; antennae with the third joint bright fulvous ; arista shortly pubescent, fusco-testaceous, with the base ochreous ; proboscis with the pale ochreous palpi and brownish oral lobes.

Thorax fusco-ochreous, with very long black bristles; halteres ochreous; scutellum with four long bristles.

Legs ochreous.

Wings mostly ochreo-testaceous with hyaline pattern; costal cell and first costal cell rather pale, with two testaceous spots in the latter; pterostigma also pale, with a patch near the transverse portion of the subcosta; from the costa, external to the pterostigma to vein $M3.+Cu1.$ (fifth longitudinal vein of Prof. BEZZI) broadly ochreo-testaceous; two triangular patches at the costa reaching to vein $R4+5.$; a very small spot in the radial cell; two small elongate spots in the fifth radial cell; first second-medial cell with a long longitudinal streak near vein $M3.+Cu1.$; a short transverse streak near the median transverse vein, across vein $M1+2.$; a large triangular patch at the posterior margin in the second second-medial cell; first cubital and anal cells hyaline, with two triangular remnants of ochreo-testaceous area in the first cubital cell on vein $M3.+Cu1.$

Abdomen shining piceous, with rather long testaceous pubescens; three basal segments with some ferrugineous shades; the basal joint of the ovipositor tubular, piceous.

Female. Length of body 5.3 mm.; length of wing 5 mm.

Described from a female specimen taken by HORII at Kagoshima, on May 13, 1913.

This species is to a certain extent allied to *Acida rioxaeformis* and *Tephrella decipiens* of BEZZI, but can easily be distinguished by the difference of its wing-markings and by many other bodily characteristics.

4. *ACIDIA MARUMOI*[1] n. sp.

(Nom. Jap. *Takane-hamadarabai.*)

(Pl. X., fig. 6,—wing.)

Allied to *Acidia erythraspis* Bezzi.

Prevailing colour of the body fuscous black; all the bristles are black.

Head with the vertex and the occiput fusco-fulvous; frons and genae fulvous; ocellar triangle and eyes greenish black; antennae fulvous with

1. Named after MARUMO who captured the specimen.

the arista black, shortly pubescent; proboscis with the palpi fulvo-ochreous.

Thorax fuscous black with long bristles; scutellum testaceous with four very long bristles.

Legs ochreous, with the tibiae testaceous.

Wings rather long, testaceous black with hyaline patches; costal cell hyaline, the first costal cell with a quadrate hyaline area in the middle; two triangular hyaline patches at the middle of the costal margin, reaching posteriorly to vein $R4+5$.; two anteriorly-directed triangular patches at the posterior margin near the apex, one, in the fifth radial cell, rather acute, and the other in the second second-medial cell rather obtuse; a hyaline streak in the first cubital cell, the posterior half of which runs along vein *Cu*2.+1st *A*., and the anterior half obliquely crosses the cell, thence reaching anteriorly to *R*1.; anal cell entirely hyaline.

Abdomen shining black, with the ventral side piceous; male genitalia prominent, testaceous with the basal part yellow.

Male. Length of body 4.5 mm.; length of wing 4.5 mm.

Described from a single male specimen taken by MARUMO, at Kamikōchi (5000 ft. high), Nagano Prefecture, on July 22, 1915.

Allied to *Acidia erythraspis* BEZZII, but can readily be distinguished by the difference of the wing-markings; it is very interesting that *erythraspis* was also captured at a locality 5000 ft. high. I name this species after MARUMO who captured it.

5. *GASTROZONA JAPONICA* n. sp.

(Nom. Jap. *Mitsumata-hamadarabai.*)

(Pl. IX., fig. 4,—wing.)

Allied to *Gastrozona fasciventris* Macquart; all the bristles are black.

Head yellow, with the ocellar triangle shining black; eyes large; antennae fulvous, with the third joint rather large and rounded at the tip; arista testaceous, shortly pubescent, with the base ochreous; clypeus rather pale; (proboscis incompletely preserved).

Thorax testaceo-piceous, shining, with the humeral callosities ochreous; a pair of lunular ochreous streaks on the sides, commencing anteriorly at the transverse suture and ending posteriorly before the scutellum; scutellum yellow, the apex black, with four strong bristles; the lateral sides of the thorax ochreous, with irregular testaceous band.

Legs ochreous, with the apical portion of femora and apical joints of tarsi fuscous.

Wings hyaline, with ochreo-testaceous bands; the basal area, from the pterostigma obliquely to the cubital cell broadly ochreo-testaceous, except a certain part of the costal and the first costal cell, which are hyaline; a broad oblique band running obliquely and inwardly from the middle of the costa to the posterior portion of vein *Cu2.*+Ist *A.*, where the latter ends at the posterior margin; externally from the anterior end of this band to the tip of the wing, the costa is broadly margined with an ochreo-testaceous band, leaving two small long patches in cell 1*R.*; from the anterior end of the oblique band mentioned before, another band arises, running outwardly and obliquely, and ending at the posterior margin; on the median transverse vein there is another band, ending at the posterior margin.

Abdomen ochreous, with the anterior margin of the second to the fourth segments (in male) or to the fifth (in female) broadly testaceous; the fifth abdominal segment of the male ochreous yellow; the basal joint of the ovipositor very conspicuous, and longer than the last four abdominal segments taken together, flattened, ferrugineo-ochreous, with testaceous apical joint.

Male. Length of body 5 mm.; length of wing 5 mm.

Female. Length of body 7 mm., length of wing 6 mm.

Described from a male and a female specimen taken at Ōji near Tokyo May 8, 1911.

A male specimen taken at the same locality on May 5, 1902, with a median testaceous band on the thorax, is probably a varietal form.

This species is, to a certain extent, allied to *Gastrozona fasciventris*

Macquart, in having an apical black spot on the scutellum, and to *G. montana* Bezzi and *G. melanista* Bezzi, in the wing-pattern. However, from the former, it differs mainly in its wing-pattern, and from the latter in the presence of a black spot on the scutellum, and from both in the markings of the thorax and the abdomen.

VII. SUMMARY.

1. The original home of the present species is Kiushiu and its distribution is strictly limited to that island only. It occurs evidently in Ōita, Miyazaki, Kumamoto, Kagoshima and Nagasaki Prefectures of the island, and is unreliably reported from Fukuoka Prefecture.

2. The destructiveness usually amounts to from 10% to 20% of the whole crop, but where it is severe it reaches 50%.

3. The present fly is a species hitherto unrecorded and I have therefore given it the new name *Dacus tsuneonis*.

4. The present species is related in its subgeneric character to *Tridacus* Bezzi, yet it bears four supra alar bristles and for this reason the new subgenus *Tetradacus* should be created to meet cases when the subgenus is required.

5. The fly usually appears at the end of June, accelerating in emergence during July and diminishing at the end of August, but its appearance is met with until September, rarely to October. At the first period of appearance males are more numerous than females but later the reverse is the case.

6. The fly appears not to live longer than one month, as far as I could conclude both from my experiments and out-door observations.

7. The fly is usually found in shady, thickly wooded places in the orchard, so that orchards either with young trees or exposed to a strong wind are usually free from its attack.

8. In nature, the fly feeds on dew on the orange-leaf or on the juice that is secreted from punctures made by the female. In experiments, pieces of pear, peach, plum, persimmon and water-melon were eaten, of

which the peach seemed to be most appreciated. "*An*" (bean-jam) was also touched.

As to liquids, citronella oil and raspberry syrup are very attractive; kerosene is not attractive.

9. The fly seems to remain in the immediate locality of its emergence, so that flies may be seen in abundance at a certain place, although in the neighbourhood they are very scarce. In experiments made by liberating marked flies the maximum distance travelled was 6 *chō* (720 yards) within three days, and the minimum 3 *chō* (360 yards) within 6 days.

10. Dispersion of the fly may be caused either by the flight of the fly or by the transportation of infested fruit (*i. e.* with maggots) by men.

11. Copulation occurs at any time of the day and lasts from 5 to 14 minutes (average 10 minutes), and takes place repeatedly.

12. To lay the egg, the ovipositor, which is just long enough to reach the pulp, is penetrated into the orange so that the "egg-puncture" is made, and eggs are laid into the juice sacs or between them, or between the pulp and the rind. Thickly-skinned oranges (navel oranges, pomelos, etc.), therefore, are usually exempt from the attack of the fly, the ovipositor possibly being unable to reach the pulp. Of mandarin oranges the "*Komikan*" (smaller varieties) are attacked more severely than the *Unshiu*.

13. In nature, infested oranges each with a single puncture are most abundantly found. Oranges with two punctures are not extremely rare, but with 3 punctures they are very rare. An orange with 4 punctures was only once reported.

14. Though it is reported by our entomologists that a single egg is laid in a puncture, as far as my observation goes there are 2–6 in each puncture. The eggs are also not infrequently laid on the surface of the fruits.

15. Though I could not determine with certainty, the fly seems not to be sexually matured until at least ten days after emergence. In

specimens that I dissected, the number of matured eggs differed in the right and left ovaries.

16. I could not ascertain how long it takes the eggs to hatch, although in one case they were not hatched until the 8th day after deposition.

17. Although the fly usually lays more than one egg in a puncture only one larva afterwards appears—as is the case in the exotic species. The cause of this I have not yet discovered.

18. Maggots appear usually at the beginning of October, measuring about 1.5 mm., and at the end of that month or at the beginning of November become full grown and measure about 13 mm.

19. Oviposition is made on the unripe, green orange; when a puncture is made, a certain portion of the rind around it becomes slightly pale. Afterwards the pale area stretches out and becomes more and more yellowish until it appears slightly reddish and extends longitudinally along the carpel (sometimes irregularly), within which the maggot is. This occurs usually in the middle of October so that that is the season best fitted for recognizing infested fruit. Later the reddish area extends wider towards the periphery and the entire rind of the orange turns yellow, so that it is very hard to distinguish infested from sound fruit. However, the oviposited part and the surroundings of the calyx are noticeably reddish in the infested orange.

20. The first carpel infested by the maggot presents a sooty unpleasant colour and is usually thinner than the remaining carpels. An orange usually contains a single originally infested carpel, yet instances of two originally infested carpels (infested respectively by two maggots) are not rare. In this case the two infested carpels are usually well separated from each other. In rare cases three or four carpels are infested but no instance of more infested carpels has yet been found.

21. When the larva has nearly eaten up the contents of the originally infested carpel, it enters the adjoining carpel and thence to the next, according to the size of the fruit, activity of the larva, and the

duration of the larval period. From two to ten carpels are infested by a single maggot. In kumquarts the boring is irregular and usually the seeds are eaten.

22. When the larva in the orange is fully developed, sooner or later the infested fruit falls. This falling of oranges begins in the month of October and continues to November. Within a few hours, or in one or more days, the larva issues from the orange, making a rather large aperture in it and enters into the ground. Occasionally the larva leaves the orange while it is still on the tree. The issuance seems to occur more vigorously at night than by day.

23. The resistance of larvae both to sea- and fresh water is very strong, especially to the latter. In experiments it seemed probable that the maggot cannot survive, if it is submerged over 10 days in sea-water or over 24 days in well-water. Moreover, five days' submergence in water can prevent, to a certain extent, the pupation and emergence of adults.

24. Larvae which have issued from the fruit penetrate into the soil usually to a depth of 1 to 2 inches and pupate. Pupation occurs from the end of November till the end of December or occasionally of January of the next year.

25. The pupa pushes off, with its frontal sac, the anterior end of the pupal case and the adult fly emerges. In experiments, burying the pupa at a depth of 1.5 ft. in the soil did not kill it.

26. The life-cycle of the fly is: Adults appear at the end of June, accelerate in emergence during July, and in August lay eggs. Larvae appear at the beginning of October, attain to maturity in November, and pupate in that month or in December, passing the winter in the pupal state and appearing the next summer as adults.

27. On oranges some other insects are found likely to be mistaken for the present species. Larvae of *Drosophila* may occur in decayed oranges. Injuries caused by wind, the sucking of Noctuid moths and the boring of Tortricid and Pyralid larvae may often be mistaken as being due to the present fly.

28. As to the methods of control: No certain parasites of this fly have yet been found; dragon-flies and Asylids possibly prey upon it. Capturing adult flies by a special apparatus, collecting and treating infested fruit in order to kill larvae and picking up the pupae are practised in the infested localities. For this purpose flies and infested fruits are purchased in Ōita Prefecture by the village offices.

29. The following recommendations are offered: (1) adults should be captured as early as possible in the season of their appearance; (2) infested fruits should be picked up as quickly as possible; (3) infested oranges should be utilized as raw material for the preparation of citric acid; (4) the construction of storehouses for oranges should be improved; (5) a full knowledge of the present species should be diffused among local orchardists.

30. Descriptions of 5 new species, which were discovered during this investigation, are appended.

March, 1918.

POSTSCRIPT.

I have described (though with some doubt) the number of the abdominal segments of the adult fly as eleven (*vide* p. 101), taking, besides the ordinary nine segments, two basal membranous segment-like portions into account. On further consideration, however, I have decided to withdraw this statement and recognize nine segments, since I find that it is a rather dogmatic opinion, so long as it is not based on any positive embryological or anatomical data.

Owing to the unusual delay in the printing of this paper—chiefly caused by the shortage of labour due to the Great War and the influenza epidemic—I regret to state that several papers on the fruit-flies, which appeared while this paper was in the press, could not be taken notice of.

January, 1919.

BIBLIOGRAPHY.[1]

1. Back, E. A. and Pemberton, C. E., 1915.—Susceptibility of citrous fruits to the attack of the Mediterranean fruit-fly.—Journ. Agric. Research, Dept. Agric., U.S.A., Vol. III., no. 4, pp. 321–330, pls. xl–xlii.
2. Back, E. A. and Pemberton, C. E., 1915.—Life history of the Mediterranean fruit-fly from the standpoint of parasite introduction.—Journ Agric. Research, Dept. Agric., U.S.A., Vol. III., no. 5, pp. 363–374, pls. xliv, xlv.
3. Back, E. A. and Pemberton, C. E., 1917.—The melon-fly in Hawaii.—United States Dept. Agric., Bull. no. 491, 64 pp., 24 pls.
4. Bezzi, M., 1913.—Indian Trypaneids (fruit-flies) in the collection of the Indian Museum. —Mem. Ind. Mus., Vol. III., no. 3, pp. 53–175, pls. viii–x.
5. Bezzi, M., 1915.—On the Ethiopian fruit-flies of the genus *Dacus*.—Bull. Ent. Research, Vol. VI., pt. II., pp. 85–101.
6. Britain, W. H., 1917.—The apple-maggot in Nova Scotia.—Prov. Nova Scotia Dept. Agric., Bull. 9, 70 pp., 6 pls.
7. Department of Agriculture, Cape of Good Hope, 1909.—The Mally fruit-fly remedy.—Cape of Good Hope, Dept. Agric. Journ., Nov. 1909, no. 49, 6 pp., 1 pl.
8. Enderlein, G., 1911.—Trypetiden-Studien.—Zool. Jahrbücher, Abteil. Syst., Geo. u. Biol. Bd. XXXI., pp. 407–460.
9. French, C., 1907.—Fruit-flies.—Dept. Agric., Victoria, Bull. no. 26, 14 pp., 1 pl.
10. Froggatt, W. W., 1916.—Fruit-flies.—Dept. Agric. New South Wales, Farmers' Bull. no. 24 (Second Edition), 54 pp., 8 pls.
11. Gurney, W. B., 1915.—Fruit-flies and other insects attacking cultivated and wild fruits in New South Wales.—Dept. Agric., New South Wales, Farmers' Bull. no. 55, 32 pp.
12. Hendel, H., 1912.—H. Sauter's Formosa-Ausbeute, Genus *Dacus*.—Suppl. Ent., no. 1, pp. 13–24, Taf. i.
13. Hendel, H., 1913.—H. Sauter's Formosa-Ausbeute, Acalyptrate Musiden (Dipt.).—Ent. Mitteil., II., Nr. 3, pp. 33–43.
14. Hewitt, C. G., 1914.—The house-fly, 382 pp., London.
15. Howlett, F. M., 1912.—The effect of oil of citronella on two species of *Dacus*.—Trans. Ent. Soc. Lond., 1912, pp. 412–418, pls. xxxix, xl.
16. Illingworth, J. F., 1912.—A study of the biology of the apple-maggot (*Rhagoletis pomonella*), together with an investigation of methods of control.—Cornell Univ. Agric. Exp. Sta. Coll. Agric. Dept. Ent., Bull. 324, pp. 129–187, figs. 16–44.
17. Kuwana, I., 1910.—Mikanbae no gakumei ni tsuite (on the scientific name of the orange fruit-fly).—Konchū-Sekai (Insect World), Vol. XIV., no. 1, p. 23.
18. Kuwana, I., 1911.—Mikanbae (orange fruit-fly).—Nōji-shikenjō Hōkoku (Report of Imperial Agricultural Experiment Station, Tokyo, Vol. XXXVIII., pp. 109–112.
19. Lowne, B. T., 1892.—The anatomy, physiology, morphology, and development of the blow-fly, Vol. I., 350 pp., 21 pls., London.
20. Maki, M., 1916.—Kankitsu no ichidai gaichū, kankitsu kwajitsubai ni tsukite (on the remarkably injurious fruit-fly that affects citrous fruit), Formosan Government Agric. Exp. Sta., Publication 86, 22 pp., 1 pl.

1 Containing only the literature actually referred to in the text.

21. MATSUMURA, S., 1895.—Thousand Insects of Japan, Vol. II., pp. 1–163, pls. xviii–xxxiv., Tokyo.
22. MATSUMURA, S., 1916.—Thousand Insects of Japan, Additamenta, Vol. II., pp. 185–474, pls. xvi–xxv., Tokyo.
23. NISHIGAYA, J., 1915.—Ōtō no daigaichū miuji ni tsuite (on very injurious maggot that affects the cherry).—Konchū-Sekai (Insect World), Vol. XIX., no. 209, pp. 52–56, pl. iv.
24. OKADA, T., 1917.—Gumi no mibai (fruit-fly of *Elaeagnus*).—Konchū-Sekai (Insect World), Vol. XXI., no. 233, pp. 7–9.
25. O'KANE, C. W., 1914.—The apple-maggot.—New Hampshire Agric. Exp. Sta., Bull. 171, 120 pp.
26. QUAYLE, H. J., 1914.—Citrus fruit insects in Mediterranean countries.—Bull. United States Dept. Agric., no. 134, 35 pp., 10 pls.
27. SEVERIN, H. P., 1912.—The flight of two thousand marked male Mediterranean fruit-flies (*Ceratitis capitata* Wied).—Ann. Ent. Soc. America, Vol. V., no. 4, pp. 400–409.
28. SEVERIN, H. P., and SEVERIN, H. C., 1913.—A historical account of the use of kerosene to trap the Mediterranean fruit-fly (*Ceratitis capitata* Wied.)—Journ. Econom. Ent., Vol. VI., no. 4, pp. 348–351.
29. SEVERIN, H. P., and SEVERIN, H. C., 1914.—Behavior of the Mediterranean fruit-fly (*Ceratitis capitata* Wied.) towards kerosene.—Journ. Anim. Behavior, Vol. IV., no. 3, pp. 223–227.
30. SEVERIN, H. P., SEVERIN, H. C. and HARTUNG, 1914.—The ravages, life-history, weights of stages, natural enemies and methods of control of the melon-fly (*Dacus cucurbitae* Coq.).—Ann. Ent. Soc. America, Vol. VII., no. 3, pp. 177–207, pls. xxvii–xxxi.
31. SEVERIN, H. P., 1917.—The currant fruit-fly.—Maine Agric. Exp. Sta., Bull. no. 264, Ent. paper, no. 96, pp. 177–246, figs. 13–17.
32. TAKAHASHI, S., 1917.—Gwaikokusan uri-mibai to naichisan uri-mibai ni tsuite (on exotic and inland melon-flies).—Byochū-gai Zasshi (Journ. of Plant Protection), Vol. IV., no. 10, pp. 14–19.

EXPLANATION OF PLATES

LIST OF ABBREVIATIONS.

a. Antenna.
a. b. Apical bristle.
a. c. o. Accessory organ.
a. g. Abdominal ganglion.
al. Alula.
al. c. Alimentary canal.
a. l. t. c. Anterior large tracheal commissure.
an. Anal lobe.
a. npl. Anterior notopleural bristle.
ar. Arista.
a. r. Antennal ridge.
a. sa. Anterior supra-alar bristle.
a. sp. Anterior spiracle.
a. s. t. c. Anterior small tracheal commissure.
a. t. s. Anterior thoracic spiracle.
C. Costal cell.
C1. Costa.
c. Clypeus.
1C. First costal cell.
c. a. Crown shaped area.
c. e. Compound eye.
c. f. Vein-like chitinied furrow.
ch. e. Chitinous elevation forming the base of the penis.
cl. Claw.
c. l. Cerebral lobe.
c. p. Chitinous piece.
c. p. s. Cephalo-pharyngeal skeleton.
c. r. Cephalic retractor muscles.
Cu. Cubital cell.
Cu1.—Cu2. First—second cubital branch.
1Cu. First cubital cell.
cx. Coxa.
c. v. Caeca of ventriculus.
d. h. s. Dorsal hypostomal sclerite.
d. p. s. Dorsal pharyngeal sclerite.
e. Epistomum.
e. d. Ejaculatory duct.
e. p. Epimeron.
eps. Episternum.
eps. sp. Combined part (?) of epimeron.
e. s. Ejaculatory sac.
ex. d. l. External dorso-lateral oblique recti muscle.
f. Frons.
1st A. First Anal.
fe. Femur.
f. h. Flat hair.
f. w. Fore wing.
g. Gena.
g. l. m. Ganglionic mass.
g. m. Gulo-mental plate.
g. s. Genal bristle
h. Haustellum.
hal. Halteres.
h. s. Hypostomal sclerite.
hu. Humeral.
h. v. Humeral vein.
i. c. p. Intermediate coxal plate.
i. d. Imaginal disk.
i. f. o. Inferior front orbital bristle.
i. l. o. Internal lateral oblique muscle.
in. d. l. Internal dorso-lateral oblique recti muscle.
int. Intestine.
i. v. b. Inner vertical bristle.
l. ep. Labrum-epipharynx.
l. i. m. Lateral intersegmental muscle.
lp. Lateral plate of mesosternum.
l. p. s. Lateral pharyngeal sclerite.
lp. sc. Lateral plate of postscutellum
l. v. l. Longitudinal ventrolateral muscle.
M. Medial cell.
m. Muscle.
m (in wing). Median transverse vein.
M1.—M3. First—Third medial branch.
2M1. First second-medial cell.
2M2. Second second-medial cell.
me. cu. Medio-cubital transverse vein.
mo. Mouth.
mpl. Mesopleural bristle.
mp. sc. Median plate of postscutellum.

ms.	Mesosternum.
m. s.	Maudibular sclerite.
m. t.	Malpighian tubes.
mts.	Metasternum.
m. t. tr.	Main tracheal trunk.
mx. p.	Maxillary palp.
nv.	Nerve.
oc.	Occiput = Epicranium (HEWITT).
oe.	Oesophagus.
o. f.	Occipital foramen.
o. l.	Oral lobe.
o. r.	Occipital row.
ov.	Ovary.
o. v. b.	Outer vertical bristle.
ov. d.	Oviduct.
ovip.	Ovipositor.
ph.	Pharynx.
p. npl.	Posterior notopleural bristle.
pr. n.	Pronotum.
prs.	Praescutum (of mesothorax).
prsc.	Praescutellar bristle.
ps.	Pseudo-trachea.
p. sa.	Posterior supra-alar bristle.
p. sp.	Posterior spiracle.
pt.	Pterostigma.
pt. b.	Pteropleural bristle.
pt. v.	Parapteron.
p. t. s.	Posterior thoracic spiracle.
pv.	Proventriculus.
pul.	Pulvillus.
R.	Radial cell.
1R.3R.5R.	First, third, fifth radical cells.
R1.—R5.	First—fifth radial branch.
r.	Rostrum.
rec.	Rectum.
rm.	Radio-medial transverse vein.
SC.	Subcosta.
sc.	Scutum of mesothorax.
scp.	Scapular bristle.
sctl.	Scutellum of mesothorax.
s. e.	Simple eye.
s. f. o.	Supra front-orbital bristle.
s. g.	Salivary gland.
sp.	Spiracle (Anterior thoracic).
sp. a.	Spiny area.
sper.	Spermatheca.
sp. p.	Spiracular processus.
s. st.	Sucking stomach.
s. t.	Sensory tubercle.
st. s. st.	Stalk of sucking stomach.
t.	Tibia.
tar.	Tarsus.
te.	Testis.
t. g.	Thoracic ganglion.
th.	Theca.
tr.	Trochanter.
tr. b.	Tracheal branch.
t. s.	Transverse suture.
un.	Uncus.
v.	Vertex.
v. d.	Vas deferens
ven.	Ventriculus
v. o.	Ventral oblique muscle.

PLATE II.

Fig. 1. *Dacus tsuneonis* Miyake, ♀. ×4.
„ 2. *Dacus bezzii* Miyake, ♀. ×4.
„ 3. Thorax of *Dacus tsuneonis* Miyake, lateral view. ×7.
„ 4. Do., showing the position of bristles. ×7.
„ 5. Terminal abdominal segments of male, dorso-posterior view. Magnified.
„ 6. Do., ventro-anterior view. Magnified.
„ 7. Do., lateral view. Magnified.

Fig. 8. Abdomen of male, lateral view. ×7.
„ 9. Abdomen of female, lateral view. ×7.
„ 10. Head, dorsal view. ×7.
„ 11. Do., dorso-anterior view. ×7.
„ 12. Do., ventral view. ×7.
„ 13. Thorax, dorsal view. ×7.
„ 14. End of abdomen of male showing the anus, posterior view. Magnified.

PLATE III.

Fig. 1. Abdomen of male, dorsal view. ×7.
„ 2. Do., ventral view. ×7.
„ 3. Abdomen of female, dorsal view. ×7.
„ 5. Do., ventral view. ×7.
„ 5. Ovipositor of *Dacus tsuneonis* Miyake. ×35.
„ 6. *Dacus* (*Chaetodacus*) *bezzii* Miyake. ×35.
„ 7. Do. of *Dacus* (*Chaetodacus*) *ferrugineus dorsalis* Hendel. ×35.
„ 8. Terminal segments of abdomen of male showing the genitalia, ventral view. (The sagittal plane of the segment is turned in the direction of the arrow, in order to make it concide with the main sagittal plane of the body). ×23.
Fig. 9. Apical portion of penis of *Dacus* (*Chaetodacus*) *bezzii* Miyake. ×80.
„ 10. Apical portion of penis of *Dacus* (*Chaetodacus*) *ferrugineus dorsalis* Hendel. ×80.
„ 11. Apical portion of penis of *Dacus tsuneonis* Miyake. ×80.
„ 12. A part of the spiral portion of penis of do. ×80.
„ 13. The network structure of the apical end of the penis. ×700.
„ 14. Right wing of *Dacus tsuneonis* Miyake. ×7.
„ 15. Apex of leg. Magnified.
„ 16. Left side legs of *Dacus tsuneonis* Miyake.
„ 17. Ovipositor of *Dacus tsuneonis* Miyake, with basal segments. ×12. 5.
18. Do. of *Dacus* (*Chaetodacus*) *bezzii* Miyake, with basal segments. ×12. 5.
19. Do. of *Dacus* (*C.*) *ferrugineus dorsalis* Hendel, with basal segments. ×12. 5.

PLATE IV.

Fig. 1. Female reproductive system.
„ 2. Alimentary system.
„ 3. Male reproductive system.
„ 4. Egg. ×35.
„ 5. Puparium, lateral view, seen from the right side. (Dotted line indicates the position of the future split.) ×5.
„ 6. Do., anterior view. ×5.
„ 7. Do., dorsal view. ×5.
„ 8. Do., posterior view. ×5.
„ 9. Female pupa, ventral view. ×6.
„ 10. Female pupa, dorsal view. ×6.
„ 11. Abdominal end of male pupa, ventral view. ×6.

PLATE V.

Fig. 1. Anterior end of full grown larva, anterior view.
„ 2. Do., ventral view.
„ 3. Cephalo-pharyngeal sclerite.
„ 4. Middle aperture of the right posterior spiracle with radiating flat hairs. × 450.
„ 5. Left anterior spiracle of *Dacus* (*Chaetodacus*) *ferrugineus dorsalis* Hendel. × 130.
„ 6. Left anterior spiracle of *Dacus tsuneonis* Miyake. × 80.
„ 7. Posterior spiracles. × 80.
„ 8. Full-grown larva, lateral view. × 7.
„ 9. Alimentary system of full-grown larva.
„ 10. Muscular system of do.
„ 11. Nervous system of do.
„ 12. Respiratory system of do.
„ 13. Anus with two lateral triangular elevations. × 45.

PLATE VI.

Fig. 1. View of the place called Nishinouchi, which is thought to be the original locality of *Dacus tsuneonis* Miyake. × indicates the spot where the orange-orchards extend to the top of the mountain range.

Fig. 2. View of the mountain-pass called Motogoye, where orange-orchards extend nearly to the highest point of the passage. The two white houses in front are the storehouses for oranges. × indicates the highest point of the passage.

In these two photographs, the dark-looking thick woods are the old orange orchards and the streaked parts indicate young orchards.

PLATE VII.

Figs. 1, 2, 3. Cross-sections of mandarin oranges (the race called *Zemmon* at Tsugumi Village) each with one originally infested carpel. Natural size. Note that the infested carpel is narrower than the others. In fig. 1, the upper carpel adjoining the infested one is also partly injured.

Figs. 4, 5. Cross-sections of mandarin oranges (*Zemmon*), with two originally infested carpels. Natural size. Note that in fig. 4, the upper infested carpel is not narrowed as is the lower. The upper adjoining carpel of the lower infested carpel in fig. 5 is also injured and is narrowed like the latter.

Fig. 6. Cross-section of a mandarin orange (*Zemmon*) with three originally infested carpels. Natural size. Note that, the infested carpel on the left is not narrowed. The carpel adjoining each infested one is also partly injured.

Figs. 7, 8. Cross-section of mandarin orange (*Zemmon*) with one originally and many subsequently infested carpels. Natural size. Note that in fig. 7, the originally infested carpel is not narrowed. It is situated in the middle on the left.

Fig. 9. Cross-section of mandarin orange with two originally infested carpels. Note that these carpels are rather close to each other.

PLATE VIII.

Figs. 1, 2. Cross-section of mandarin orange, variety *Unshiu*, with one originally infested carpel. Natural size.

Figs. 3, 4. Cross section of do., with two originally infested carpels. Natural size. Note that the adjoining carpels of the infested carpels in fig. 4 are also injured.

Figs. 5, 6. Longitudinal section of kumquart (variety *Marumi*) infested by *Dacus tsuneonis* Miyake. Natural size. Note that the seeds are eaten.

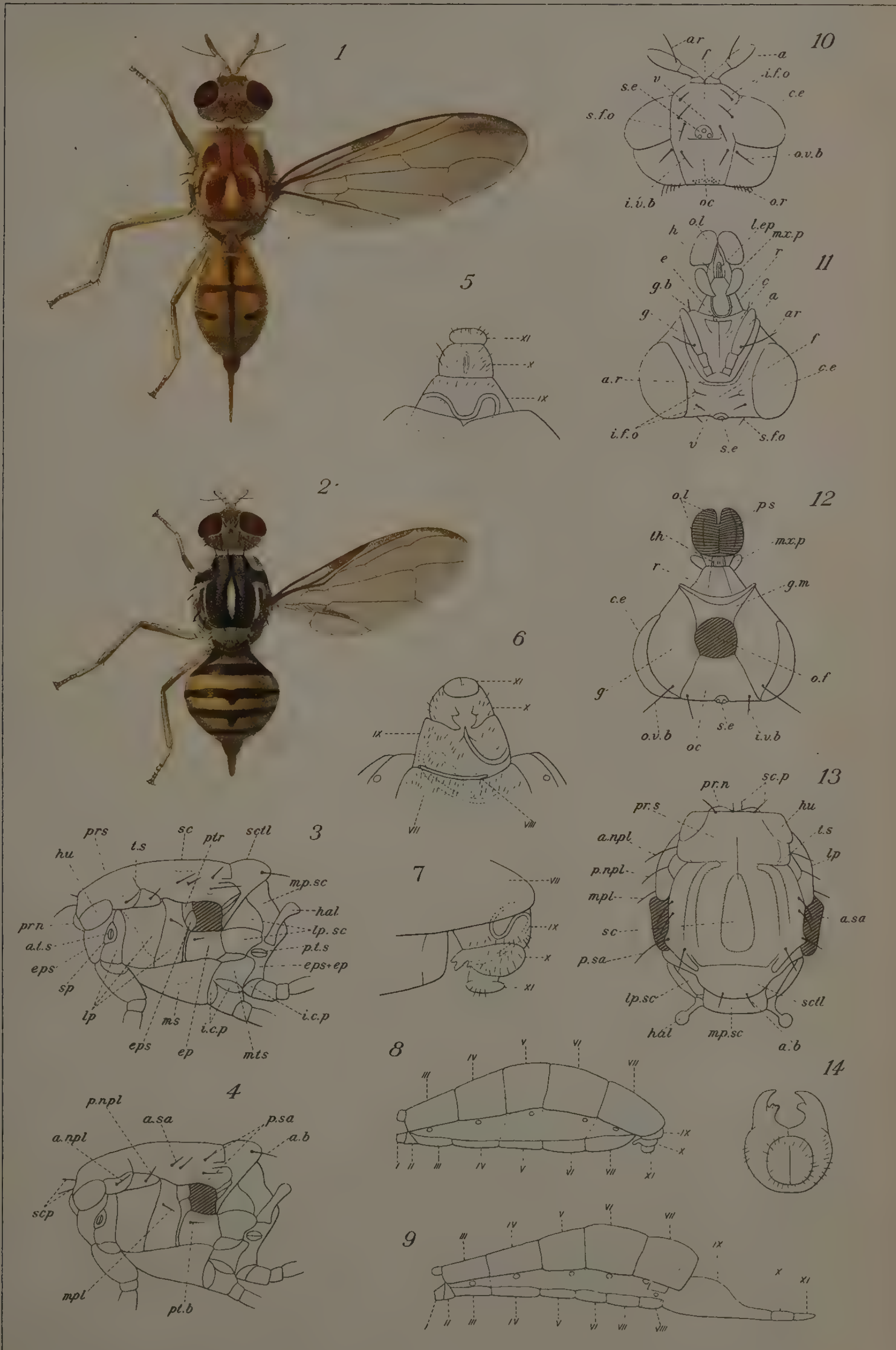
Figs. 7, 8. Cross-section of do. Natural size. Note that seeds are eaten, and in the example of fig. 8 there are crevices in the carpels, where the maggot has been burrowing, eating up the contents.

PLATE IX.

Steaming infested oranges at Tsugumi Village, to exterminate orange-maggots.

PLATE X.

Fig. 1. Right wing of *Dacus tsuneonis* Miyake. × 9.
" 2. Do. of *Dacus* (*Chaetodacus*) *bezzii* Miyake. × 12.
" 3. Do. of *Hypenidium polyfasciatum* Miyake. × 12.
" 4. Do. of *Gastrozona japonica* Miyake. × 12.
" 5. Do. of *Acidia kagoshimensis* Miyake. × 12.
" 6. Do. of *A. marumoi* Miyake. × 12.



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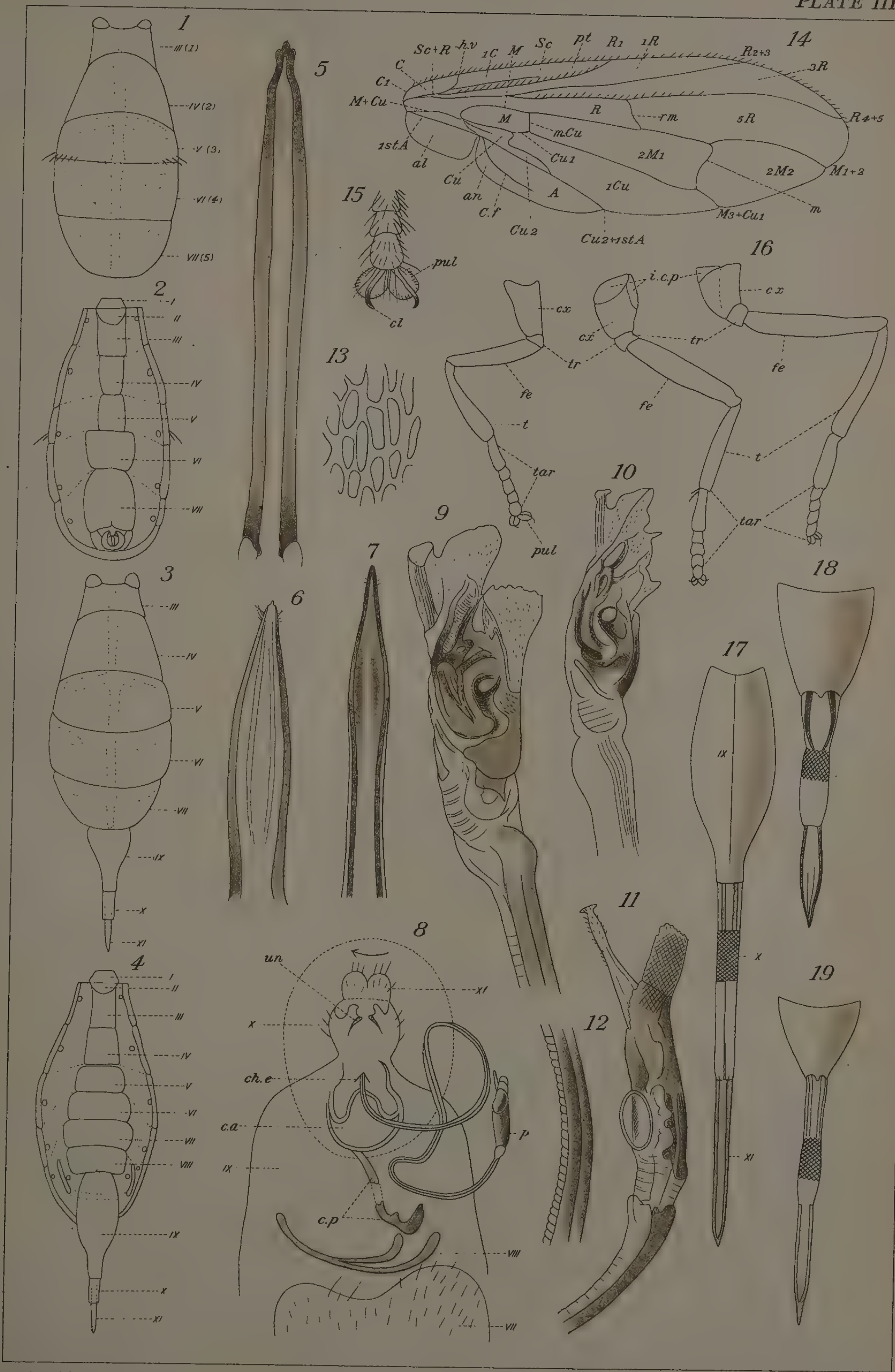
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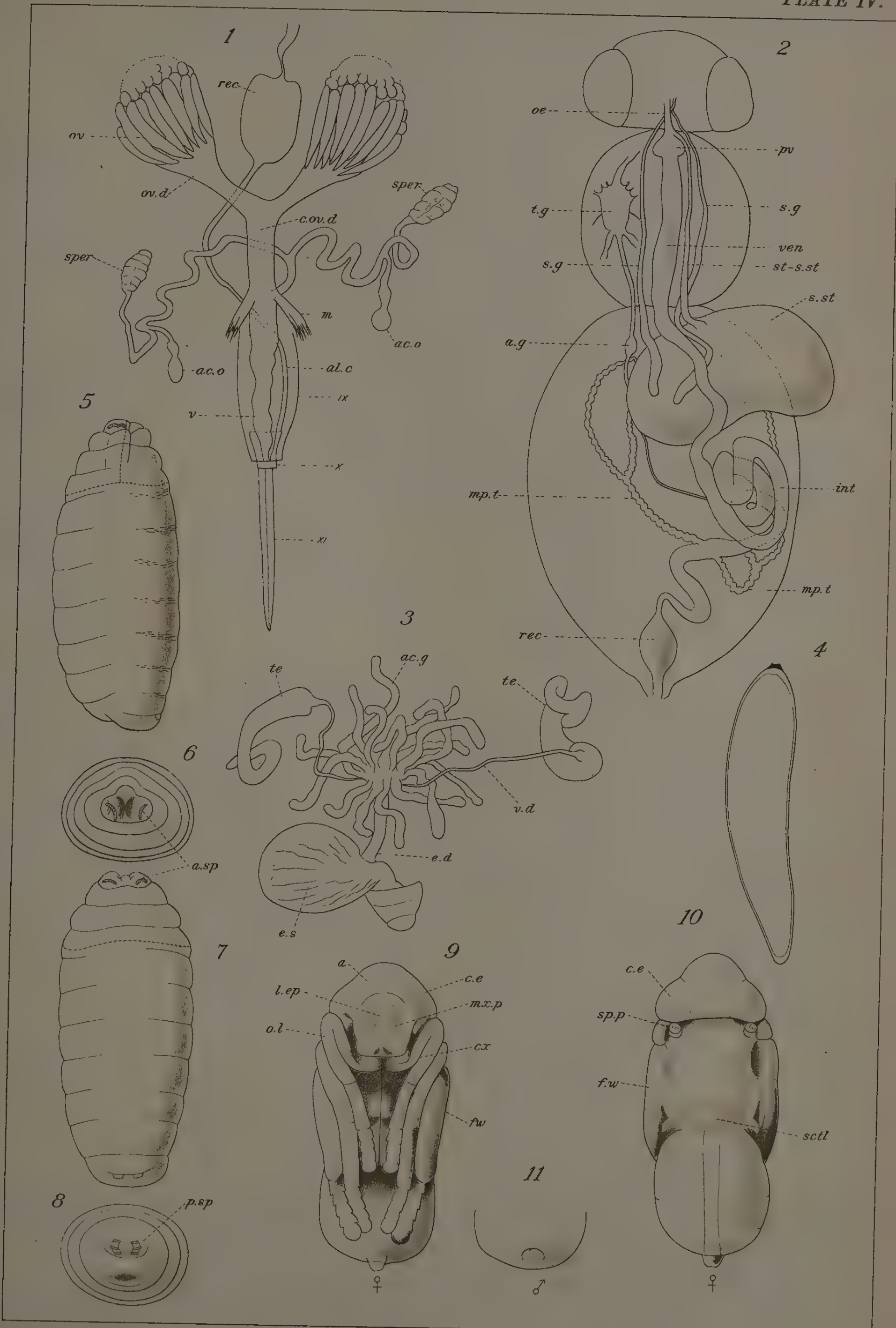
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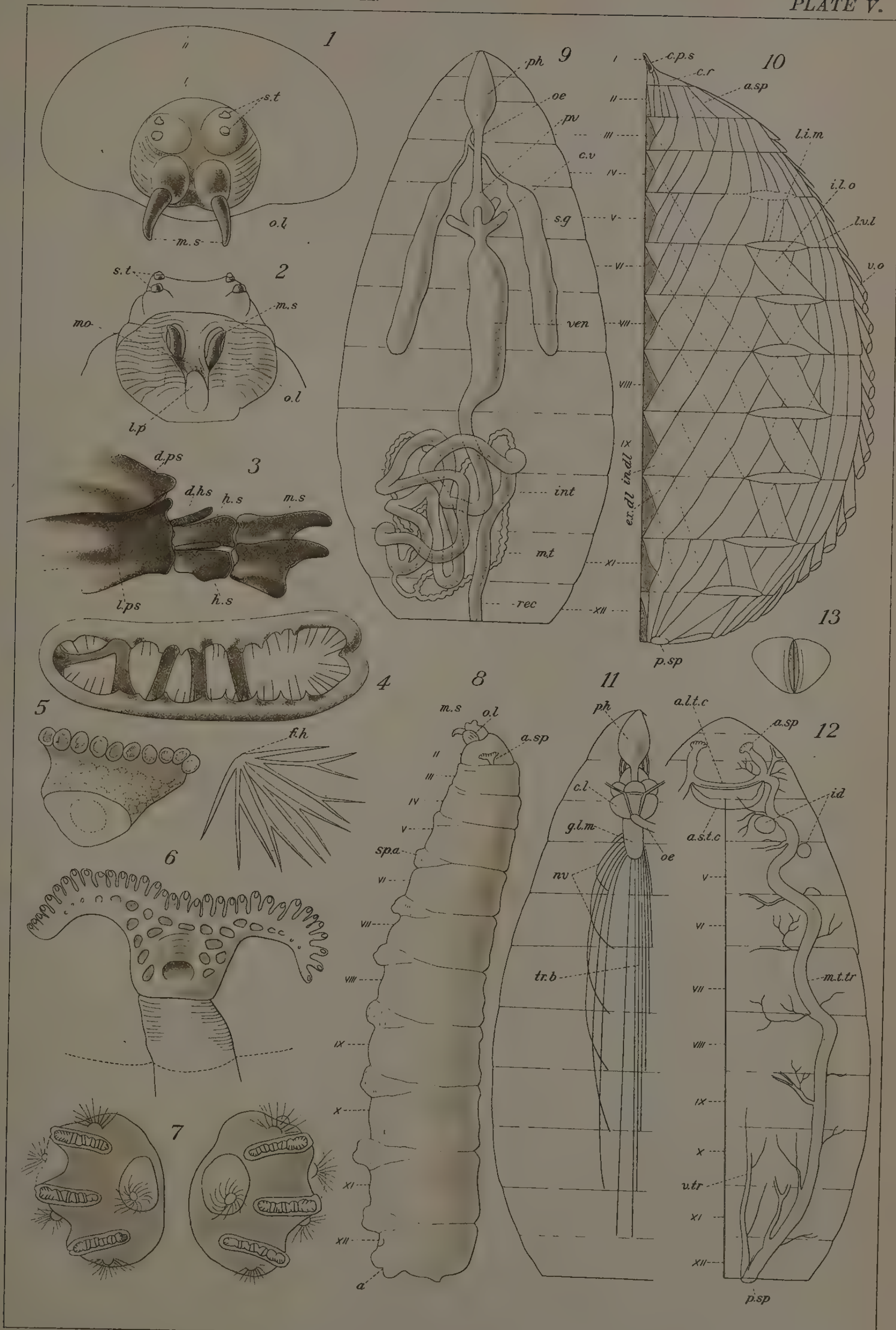
PLATE V.



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T. Miyake photo.

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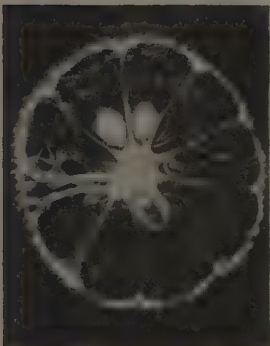

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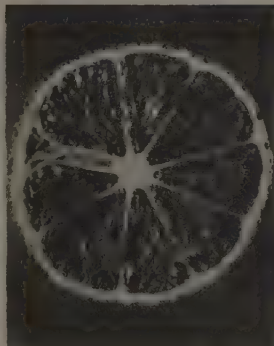

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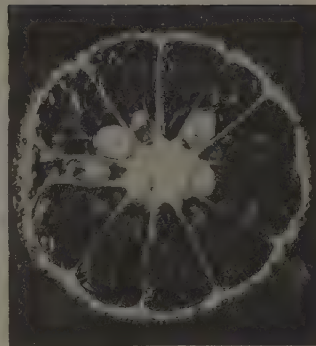

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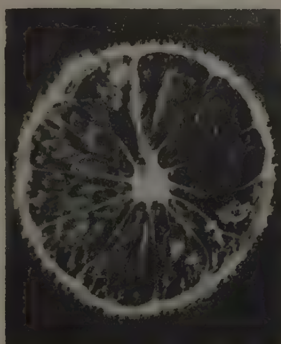

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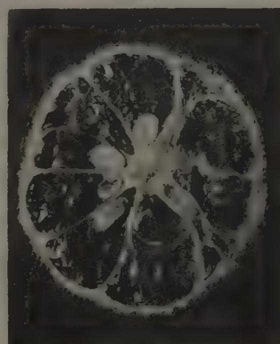

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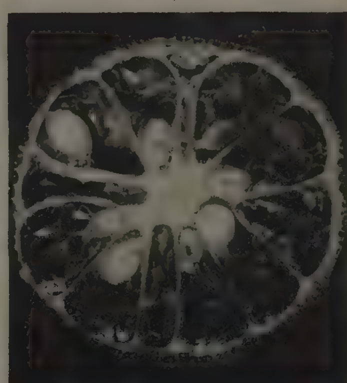

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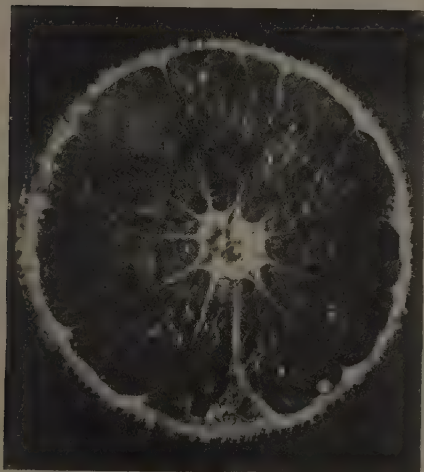

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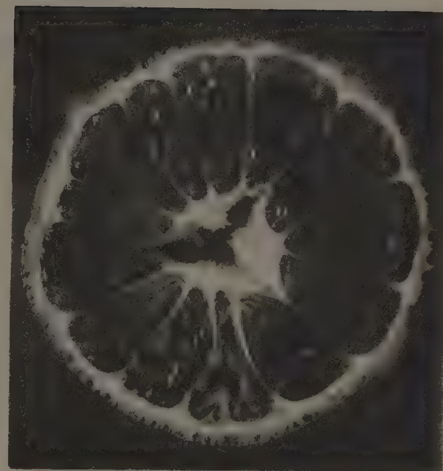

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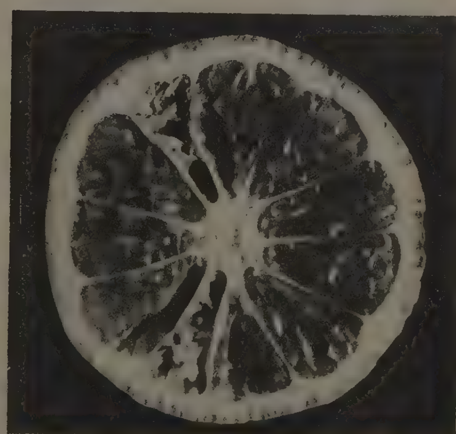

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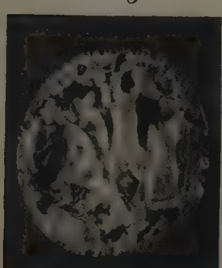

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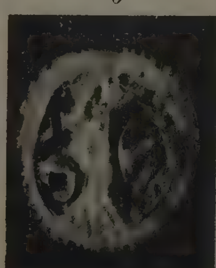

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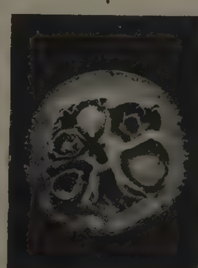

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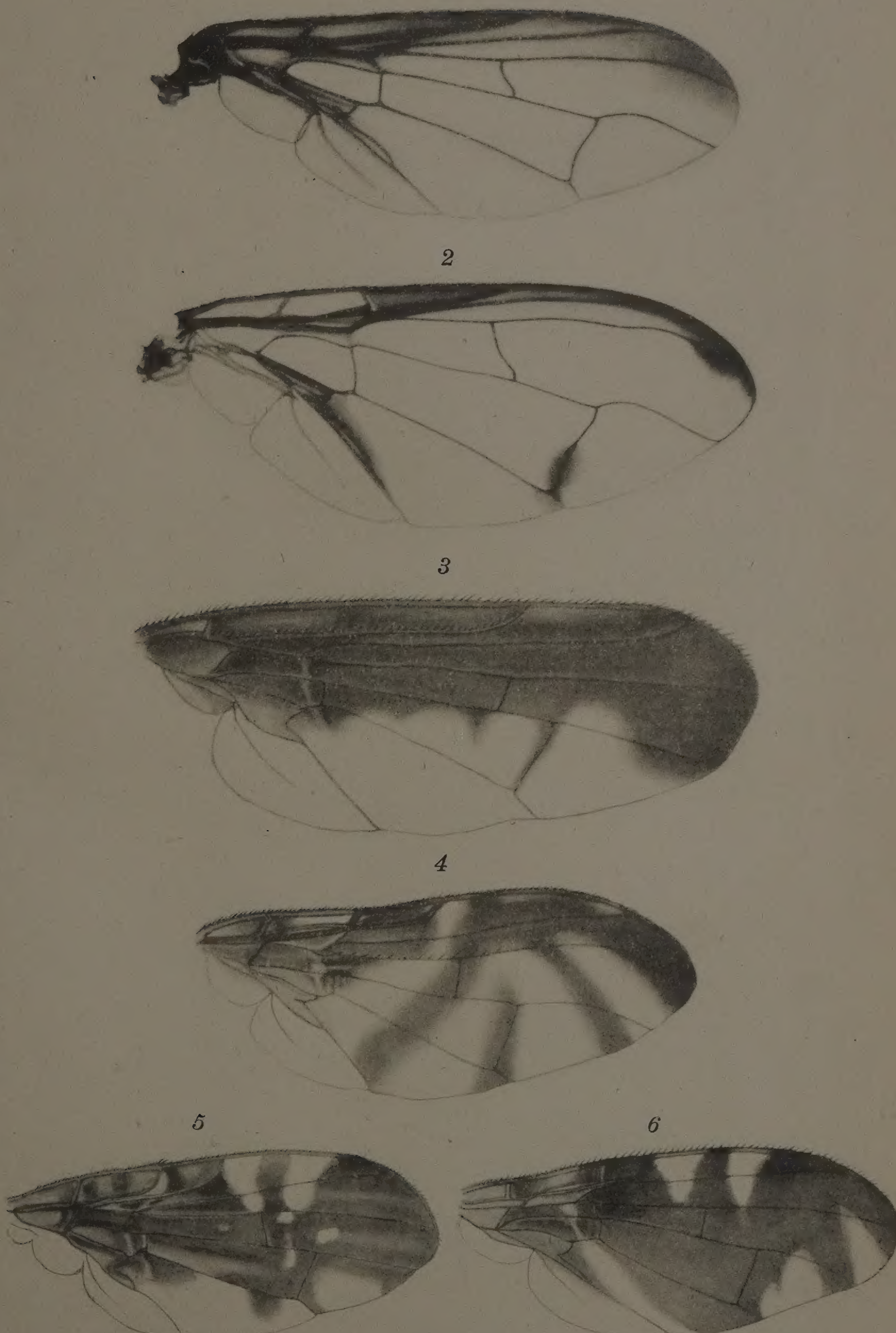

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